SenseLink™ QM

MVA For Injection Molding

User Manual

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Preface

About this addendum

This addendum is designed to serve as a guideline to the installation, set up, operation, and basic maintenance of the Remote Monitoring Unit (RMU) with the SenseLink™ QM MVA Controller features. The information contained within this manual, including product specifications, is subject to change without notice. Please observe all safety precautions and use appropriate procedures when handling the SenseLink™ QM hardware product and its related software.

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1 General Information

The SenseLink™ QM is a data collection and monitoring device targeted for the injection molding industry. The SenseLink provides a complete system for injection molding multivariate analysis and real time quality and fault detection. The SenseLink converts electrical and serial data into an archived, ethernet network available format.

For a complete list of models at the time of this printing, see Appendix.

1.1 Conventions used in this User Manual

Warning	**The WARNING sign denotes a hazard to personnel. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.**
Caution	**The CAUTION sign higlights information that is important to the safe operation of the BlueBox, or to the integrity of your files. .**
Note	**THE NOTE SIGN DENOTES IMPORTANT INFORMATION. IT CALLS ATTENTION TO A PROCEDURE, PRACTICE, CONDITION, OR THE LIKE, WHICH IS ESSENTIAL TO HIGHLIGHT.**

On screen buttons or menu items appear in bold and cursive.
Example: Click ***OK*** to save the settings.

Keyboard keys appear in brackets.
Example: [ENTER] and [CTRL]

Pages with additional information about a specific topic are cross-referenced within the text.
Example: (See page xxx)

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2 Overview

The SenseLink provides a comprehensive system for modeling a process in real-time, providing predictive results which predict the quality of the part immediately upon being processed. The system resides in parallel with the process controller, minimizing any impact on the existing process.

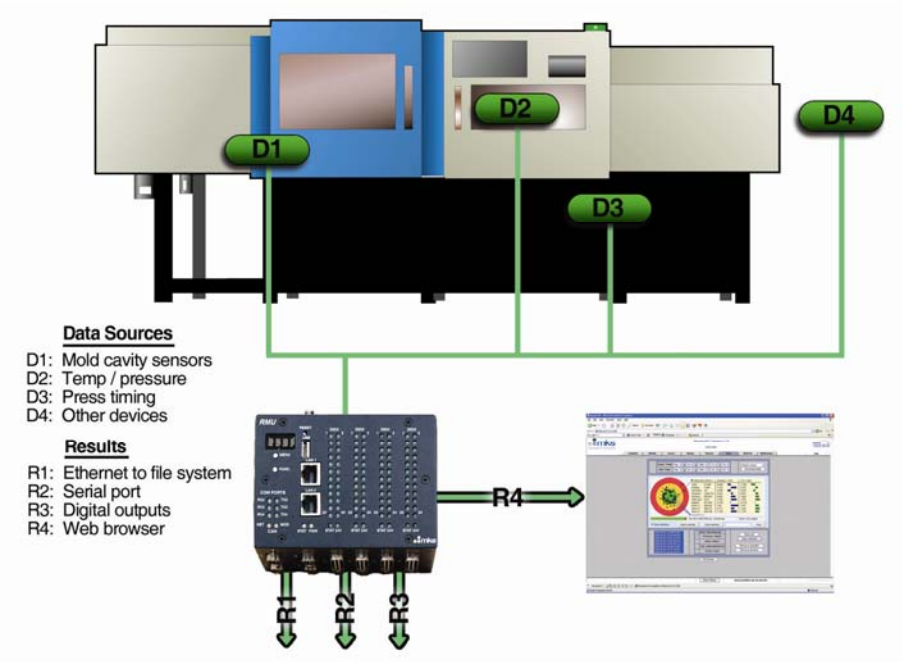

Figure 1 Connection to Injection Molding Machine

The SenseLink technology detects process deviations in real time and makes an accept or reject decision based on multivariate statistics. This multivariate analysis provides a contribution chart with information describing the root cause or interactions that contributed to the rejection of that suspect part.

2.1 Theory of Operation

The SenseLink QM provides complete data acquisition and modeling functionality, for determining process results in real-time, all contained in a single unit with no additional software required.

Setup

a) SenseLink is initially used as a general purpose data acquisition system, where the system connects to the key process signals of the molding machine and calculates the most important features of each signal.

b) A Design of Experiment (DOE) is run to gather process data and to induce process variation. The DOE limits should be designed so that all molded parts are acceptable.

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c) A multivariate model is then created within the SenseLink, from the DOE, which captures the acceptable operating window of the specific product.

d) Each new molded part is then compared to the multivariate model, where an accept or reject decision is made.

e) Validation experiments are then run to refine the alarm limits of the model and to ensure 100% quality assurance.

Data Acquisition
The system connects to all process variables via analog, digital, serial, or ethernet based devices. It collects data at a user defined rate, and publishes data to the modeling engine and archive database.

Multi-Variate Analysis (MVA)
The SenseLink creates a model using data from the DOE or from some historical data set that resulted in 100% acceptable parts. Any new parts are then compared to this known "good" model, and results such as T^2, DModX, and contributions are determined. The results are then returned to the control engine.

Control Engine
Receives the results from the MVA and determines whether the last process is "passed" or "rejected". Logic is then enacted based upon this determination.

SenseLink QM
An s/w application running on the SenseLink hardware provides the functionality for all data acquisition, control, and user interface (UI). The Linux PC acts as a data storage server and MVA host creating a complete single unit implementation of MVA control.

2.2 Process Variables

The SenseLink connects to existing process signals including screw position, pressure, and temperatures along with digital signals such as filling, packing, and screw recovery to determine the different states of the molding process.

2.2.1 Digital Variables

SenseLink QM requires information about the current process states. The digital signals provide the system with the ability to calculate important process characteristics during each of the process states. The digital inputs also define the processing window for data analysis.

Table 1 Digital Signals for Injection Molding Process

ID	Description	Unit	Further information
DI1	**Mold Close**	24V	Mold clamped state, mold open signal can alternatively be used
DI2	**Fill**	24V	Process state where cavity is filling with injection speed
DI3	**Hold**	24V	Process state where cavity is packing/holding with pressure
DI4	**Plastication**	24V	Process state where screw is rotating/extruding to build up shot

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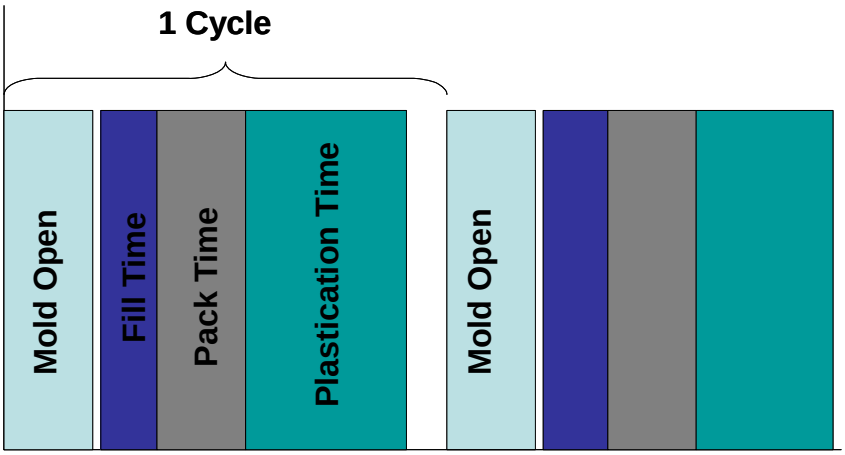

Figure 2 Injection Molding Digital Process States

2.2.2 Analog Variables

The analog variables provide the system data for analysis. Multiple important process features are calculated from each analog variable.

Table 2 Analog Signals for Injection Molding Process

ID	Analog Variables	Units	Description
AI1	**Nozzle Temp**	°C	Temp measure at barrel nozzle
AI2	**Barrel Zone 1 Temp**	°C	Barrel temp measured in zone 1
AI3	**Barrel Zone 2 Temp**	°C	Barrel temp measured in zone 2
AI4	**Barrel Zone 3 Temp**	°C	Barrel temp measured in zone 3
AI5	**Injection Pressure**	MPa	Hydraulic or plastic pressure
AI6	**Screw Position**	mm	Axial displacement of screw
AI7	Screw Velocity	mm/s	Velocity of axial movement of screw
AI8	Clamp Force	Tons	Tonnage to clamp mold halves
AI9	Screw Rotational Speed	RPM	Screw rotational speed during screw recovery
AI10	Cavity Pressure	MPa	Pressure measured in mold cavity
AI11	Cavity Temp	°C	Temp measured in mold cavity
AI12	Barrel Temp Zones	°C	Any additional barrel temp zones
AI13	Hot Runner Temps	°C	Any manifold or tip temperatures

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2.3 Process DOE

The requirements of the DOE are to teach SenseLink the processing window, to induce process variation, and to develop process data relationships based on the various combinations of process inputs.

Table 3 Injection Molding Sample DOE

Run	Shot Size	Injection Velocity	Pack Pressure	Screw RPM	Barrel Temp	Mold Temp	Cooling Time
1	-1	-1	1	1	-1	-1	1
2	1	1	-1	1	-1	-1	-1
3	-1	1	1	-1	-1	1	-1
4	1	-1	-1	-1	-1	1	1
5	0	0	0	0	0	0	0
6	-1	1	-1	-1	1	-1	1
7	1	-1	1	-1	1	-1	-1
8	-1	-1	-1	1	1	1	-1
9	1	1	1	1	1	1	1

The DOE design space should be carefully designed by the customer or by Umetrics based on the customers needs. The DOE should be created with as wide a processing window possible while still creating 100% good parts. The average of high and low limits should be the optimum part and at least one DOE run should be done at that median factor level. The SenseLink creates models based on the DOE, so the design and time put into the DOE and measuring the parts is of utmost importance.

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3 Quick-Start Installation

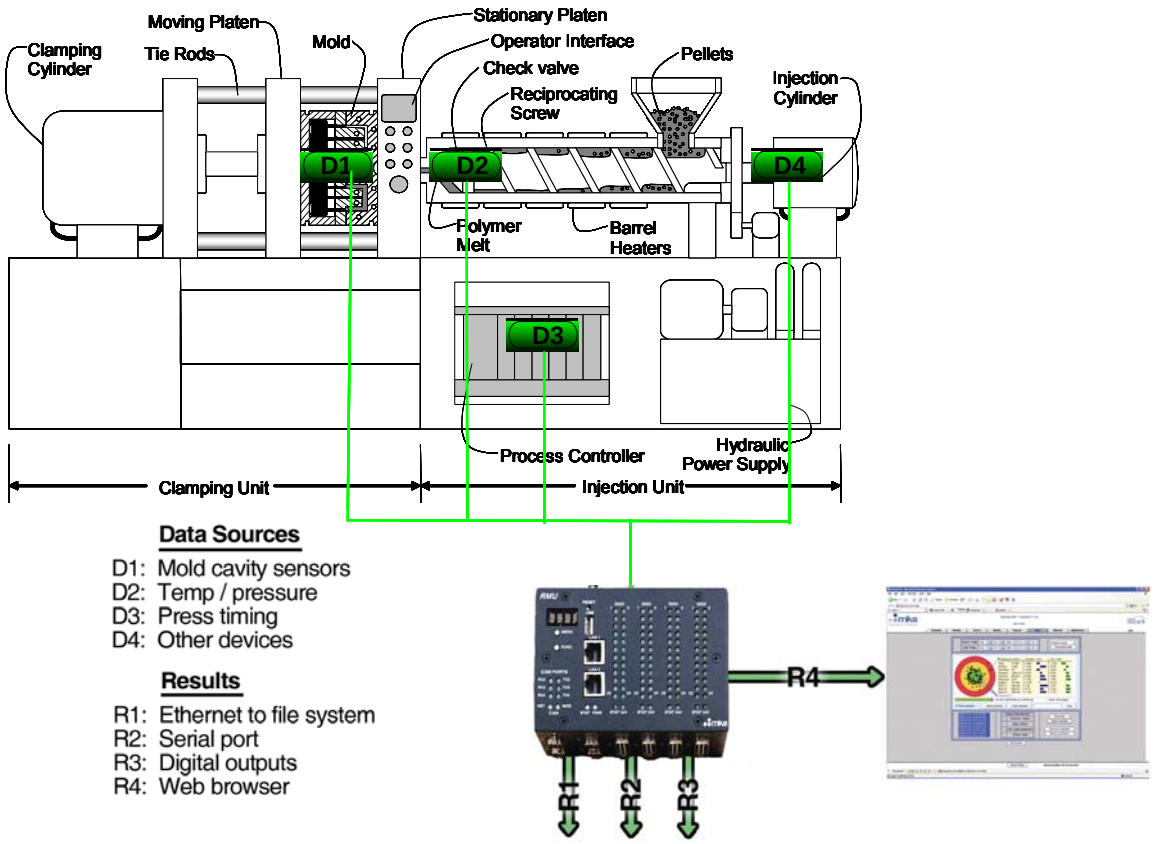

Figure 3 Injection Molding Machine/SenseLink Interconnect

SenseLink hardware resides on the tool and may contain the following connections:

- Power, 24VDC at 1 amp
- Analog inputs (up to 16), specified as either Differential or Single-Ended, 12 bit
- Digital inputs, active low, opto-coupler input
- Digital output, contact closure, normally open, 1A
- Serial RS232/485, 2 channels, for data acquisition from intelligent devices
- Ethernet, 10BT, RJ45 for data acquisition from intelligent devices and link to SenseLink network

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4 Quick-Start for MVA Control

4.1 Introduction

Mount and connect the SenseLink to the system.

Once the SenseLink is connected electrically, the following configuration will occur:

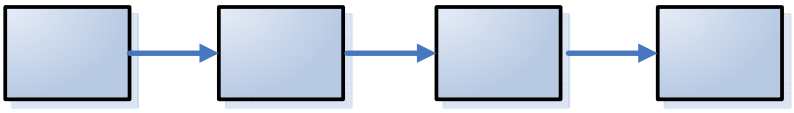


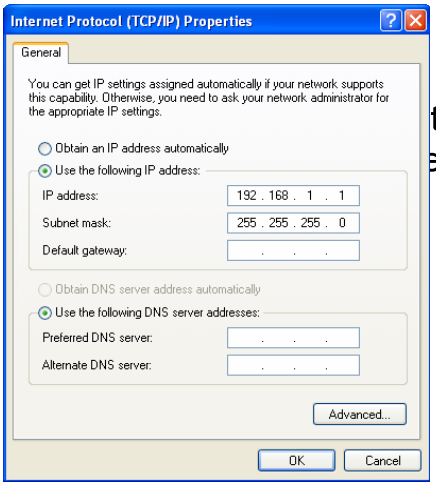
Figure 4 SenseLink Setup

4.2 Connect

1. Power up Senselink by attaching power connector and plugging in 24VDC power supply to 110VAC.

2. Attach ethernet cable to Senselink LAN 2 and your PC.

3. Modify your network TCP/IP settings to match the following (PC IP address should have same base IP address as LAN 2 port which is displayed on unit screen):
   PC IP Address: 192.168.1.1
   PC Netmask: 255.255.255.0


Internet Protocol (TCP/IP) Properties
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address:
192 . 168 . 1 . 1
Subnet mask:
255 . 255 . 255 . 0
Default gateway:
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server:
Alternate DNS server:
Advanced...
OK
Cancel

to
es

COLLECT
Data

Figure 5 TC/IP Properties

Note Custom SenseLink™ QM solutions may have a configuration requiring different default settings. For custom applications refer to the addendum for specific default settings

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4. Open up your web browser and enter the address of the LAN 2 port 192.168.1.2. You will then be prompted for a password. Enter “user” for both username and password. You will see the main SenseLink™ QM configuration page. There is slight delay as the unit transfers items to your local browser.

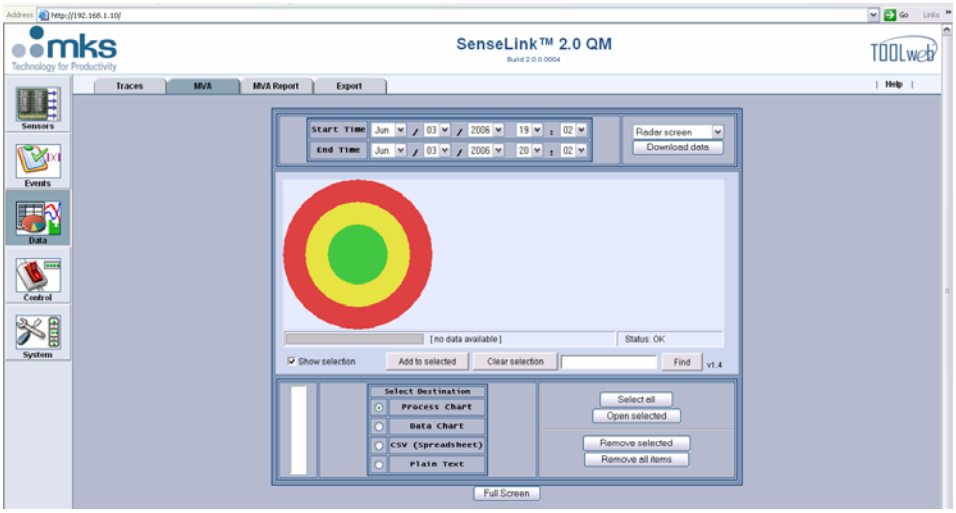

Figure 6 SenseLink Main Page

5. Click on the ***Traces*** tab, which will show you the current, running data collection plans. Collection plan DataCP is by default configured with only virtuals for model creation and Test is configured with raw data.

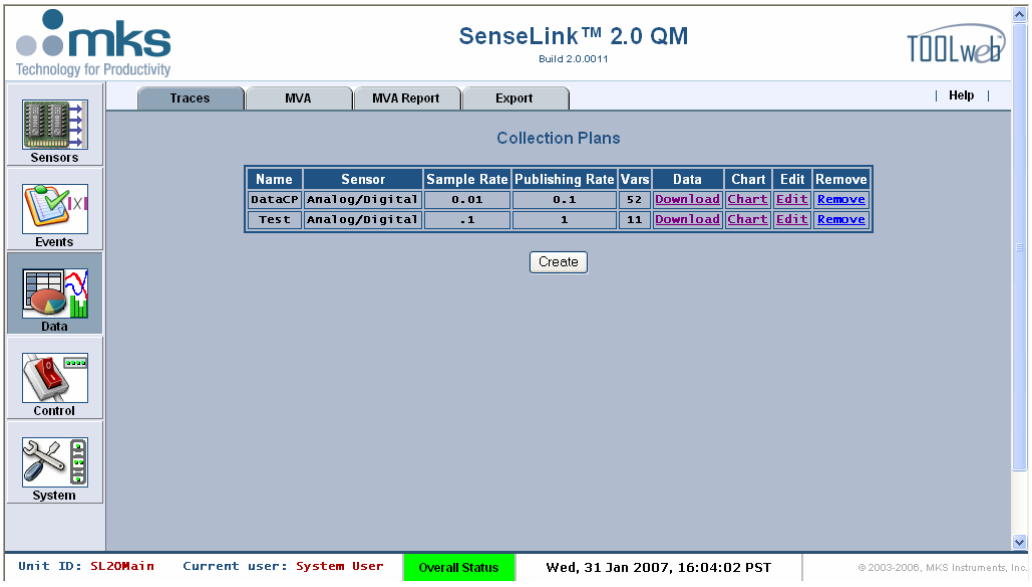

Figure 7 Traces Main Page

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6. Select ***Chart*** for collection plan Test and a new browser window will open up. Raw data that has been collected will appear for graphical analysis. There are many data viewing options available using this graph.

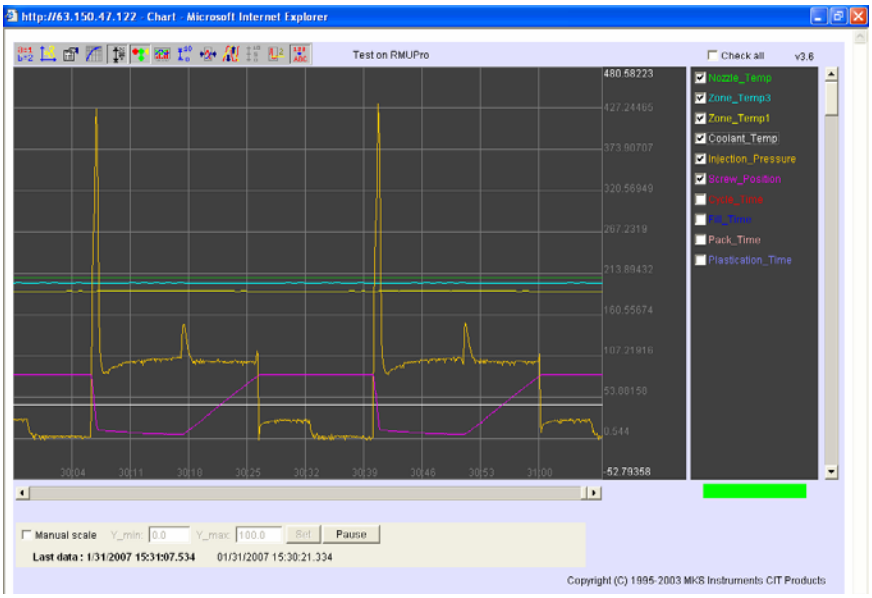

Figure 8 Traces Chart

7. Transport the collected raw data to your PC. Under the same ***Traces*** tab, in the Download Data column, select ***Download***. A page will open to provide options on the timeframe of data you would like to access.

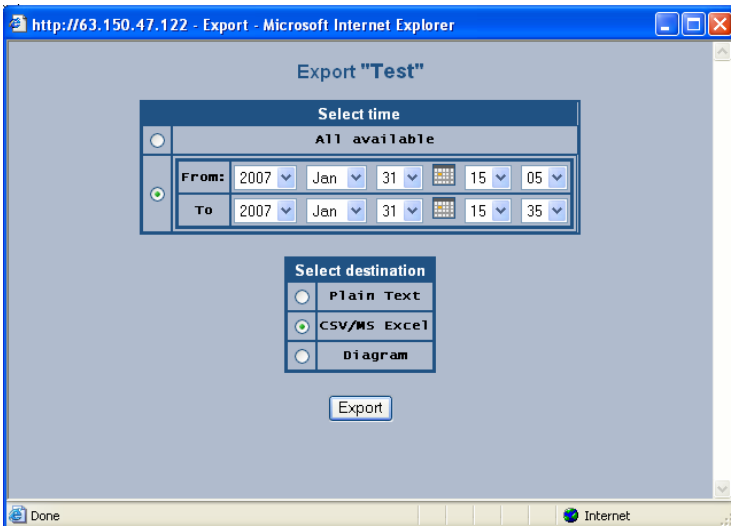

Figure 9 Exporting Collection Plan

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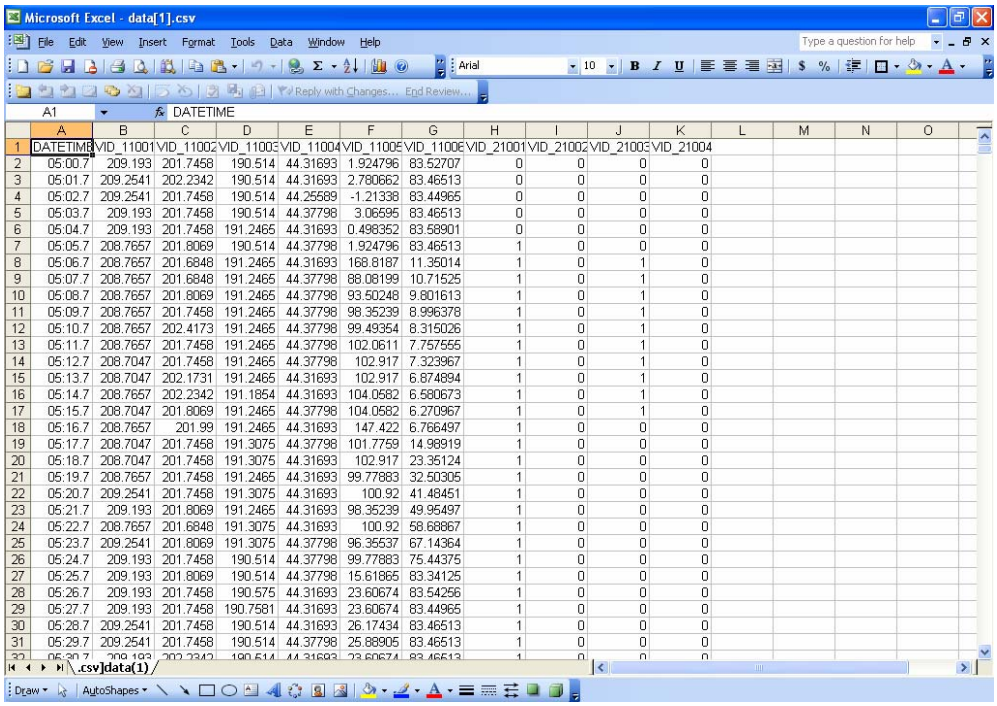
8. Click on ***Export*** and the data will be sent to your PC for plain text, MS-Excel format, or graphical viewing.



	A	B	C	D	E	F	G	H	I	J	K
1	DATETIME	VID_11001	VID_11002	VID_11003	VID_11004	VID_11005	VID_11006	VID_21001	VID_21002	VID_21003	VID_21004
2	05:00.7	209.193	201.7458	190.514	44.31693	1.924796	83.52707	0	0	0	0
3	05:01.7	209.2541	202.2342	190.514	44.31693	2.780662	83.46513	0	0	0	0
4	05:02.7	209.2541	201.7458	190.514	44.25589	-1.21338	83.44965	0	0	0	0
5	05:03.7	209.193	201.7458	190.514	44.37798	3.06595	83.46513	0	0	0	0
6	05:04.7	209.193	201.7458	191.2465	44.31693	0.498352	83.58901	0	0	0	0
7	05:05.7	208.7657	201.8069	190.514	44.37798	1.924796	83.46513	1	0	0	0
8	05:06.7	208.7657	201.6848	191.2465	44.31693	168.8187	11.35014	1	0	1	0
9	05:07.7	208.7657	201.6848	191.2465	44.37798	88.08199	10.71525	1	0	1	0
10	05:08.7	208.7657	201.8069	191.2465	44.37798	93.50248	9.801613	1	0	1	0
11	05:09.7	208.7657	201.7458	191.2465	44.37798	98.35239	8.996378	1	0	1	0
12	05:10.7	208.7657	202.4173	191.2465	44.37798	99.49354	8.315026	1	0	1	0
13	05:11.7	208.7657	201.7458	191.2465	44.37798	102.0611	7.757555	1	0	1	0
14	05:12.7	208.7047	201.7458	191.2465	44.37798	102.917	7.323967	1	0	1	0
15	05:13.7	208.7047	202.1731	191.2465	44.31693	102.917	6.874894	1	0	1	0
16	05:14.7	208.7657	202.2342	191.1854	44.31693	104.0582	6.580673	1	0	1	0
17	05:15.7	208.7047	201.8069	191.2465	44.37798	104.0582	6.270967	1	0	1	0
18	05:16.7	208.7657	201.99	191.2465	44.31693	147.422	6.766497	1	0	0	0
19	05:17.7	208.7047	201.7458	191.3075	44.37798	101.7759	14.98919	1	0	0	0
20	05:18.7	208.7047	201.7458	191.3075	44.31693	102.917	23.35124	1	0	0	0
21	05:19.7	208.7657	201.7458	191.2465	44.31693	99.77883	32.50305	1	0	0	0
22	05:20.7	209.2541	201.7458	191.3075	44.31693	100.92	41.48451	1	0	0	0
23	05:21.7	209.193	201.8069	191.2465	44.31693	98.35239	49.95497	1	0	0	0
24	05:22.7	208.7657	201.6848	191.3075	44.31693	100.92	58.68867	1	0	0	0
25	05:23.7	209.2541	201.8069	191.3075	44.37798	96.35537	67.14364	1	0	0	0
26	05:24.7	209.193	201.7458	190.514	44.37798	99.77883	75.44375	1	0	0	0
27	05:25.7	209.193	201.8069	190.514	44.37798	15.61865	83.34125	1	0	0	0
28	05:26.7	209.193	201.7458	190.575	44.31693	23.60674	83.54256	1	0	0	0
29	05:27.7	209.193	201.7458	190.7581	44.31693	23.60674	83.44965	1	0	0	0
30	05:28.7	209.2541	201.7458	190.514	44.31693	26.17434	83.46513	1	0	0	0
31	05:29.7	209.2541	201.7458	190.514	44.37798	25.88905	83.46513	1	0	0	0

Figure 10 Raw Data

9. Now you are ready to customize the SenseLink™ QM for your applications. The following features can be quickly customized for your application:

- Scale all values to real units. Also collect min, max, average, derivative, and integral values.
- Change the frequency of data collection
- Modify the alarm logic using complex expressions
- Email based on alarm events
- Graph and analyze data
- Change network settings

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4.3 Customizing Analog Inputs

Select the ***Analog*** tab and choose ***Edit Inputs***.

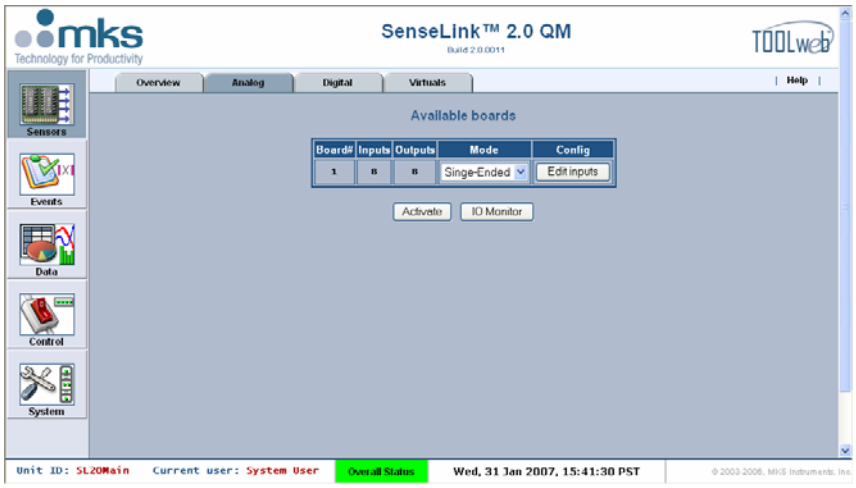

Figure 11 Analog Boards

Edit the input names and scale each signal. Depending on the amount of sensors, multiple analog boards may need to be used. Once all of the names and scaling are entered, select ***Save*** and then select ***Activate*** from the Analog tab.

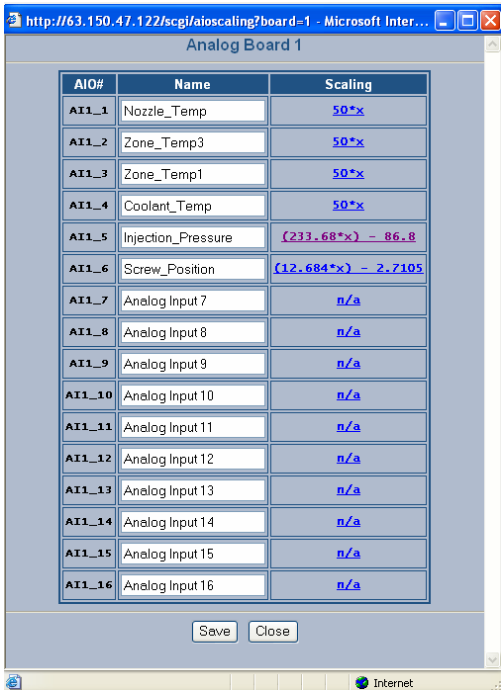

Figure 12 Editing Analog Signals Board 1

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Open the ***I/O Monitor*** to make sure each point is reading a correct value.

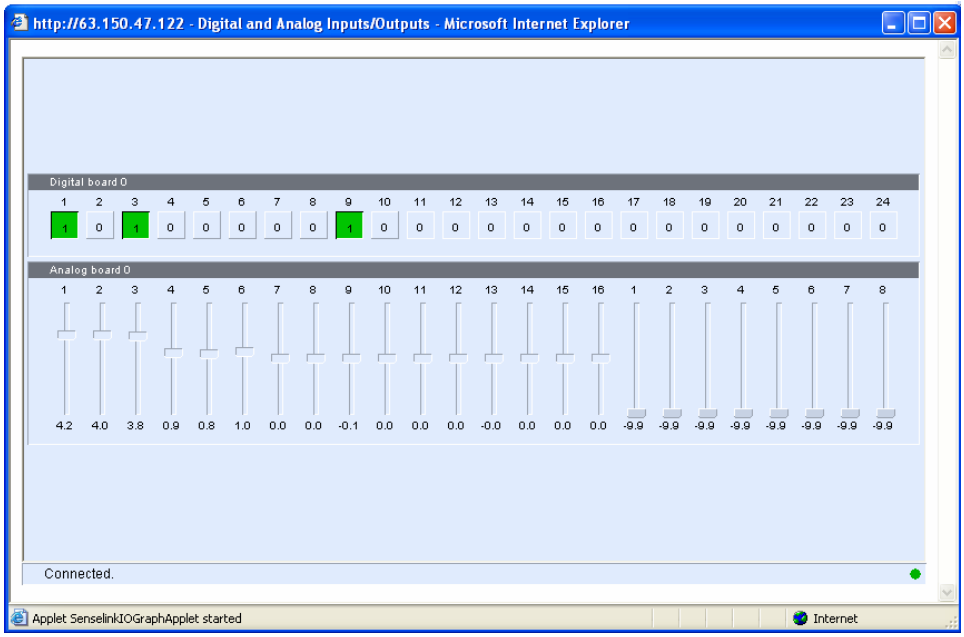

Figure 13 IO Monitor

4.4 Customizing Digital Inputs

Configure each point as in/out and enter the name of the signals. Select ***Save*** when complete.

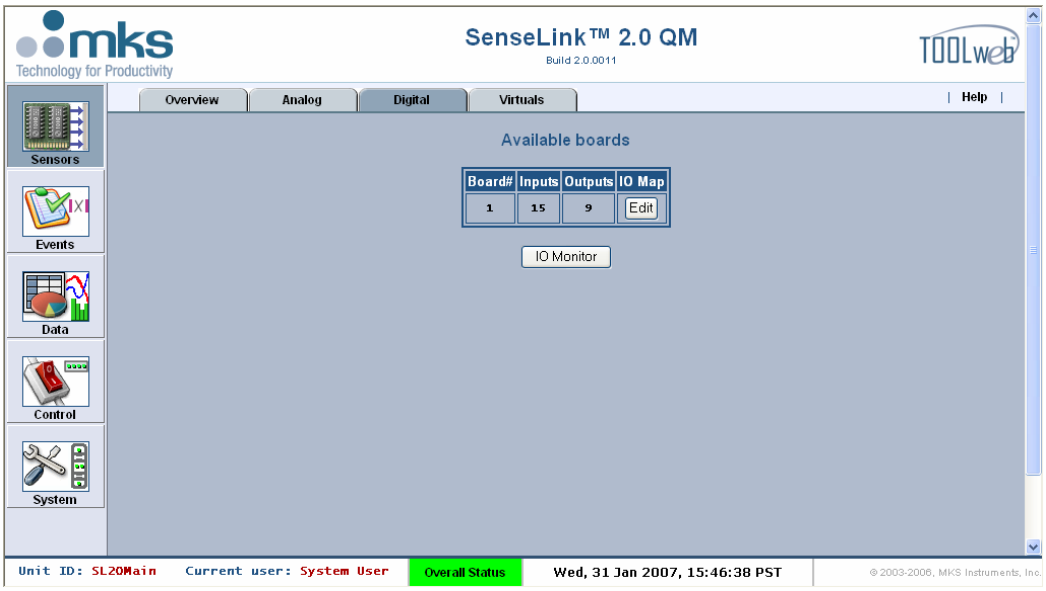

Figure 14 Digital Boards

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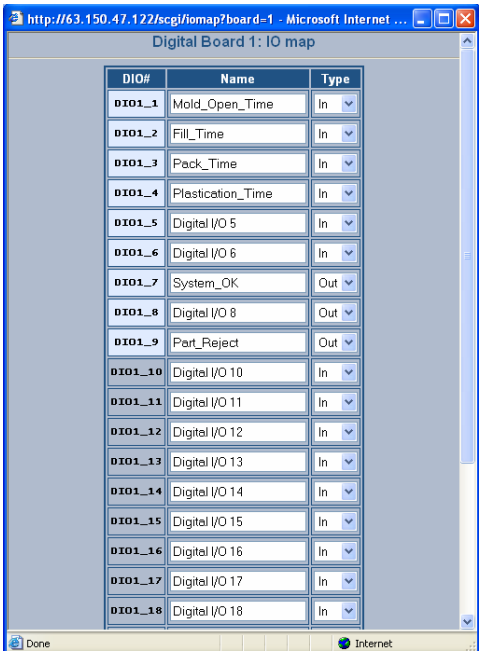
http://63.150.47.122/scgi/iomap?board=1 - Microsoft Internet ...
Digital Board 1: IO map
DIO# Name Type
DIO1_1 Mold_Open_Time In
DIO1_2 Fill_Time In
DIO1_3 Pack_Time In
DIO1_4 Plastication_Time In
DIO1_5 Digital I/O 5 In
DIO1_6 Digital I/O 6 In
DIO1_7 System_OK Out
DIO1_8 Digital I/O 8 Out
DIO1_9 Part_Reject Out
DIO1_10 Digital I/O 10 In
DIO1_11 Digital I/O 11 In
DIO1_12 Digital I/O 12 In
DIO1_13 Digital I/O 13 In
DIO1_14 Digital I/O 14 In
DIO1_15 Digital I/O 15 In
DIO1_16 Digital I/O 16 In
DIO1_17 Digital I/O 17 In
DIO1_18 Digital I/O 18 In
Done
Internet

Figure 15 Editing Digital Signals

4.5 Virtuals

Under the ***Virtuals*** tab, data features can be calculated using arithmetic expressions and functions based on the analog and digital process signals. A default set of data features will be provided based on the users available signals. Any new data features can then be easily added by the user.

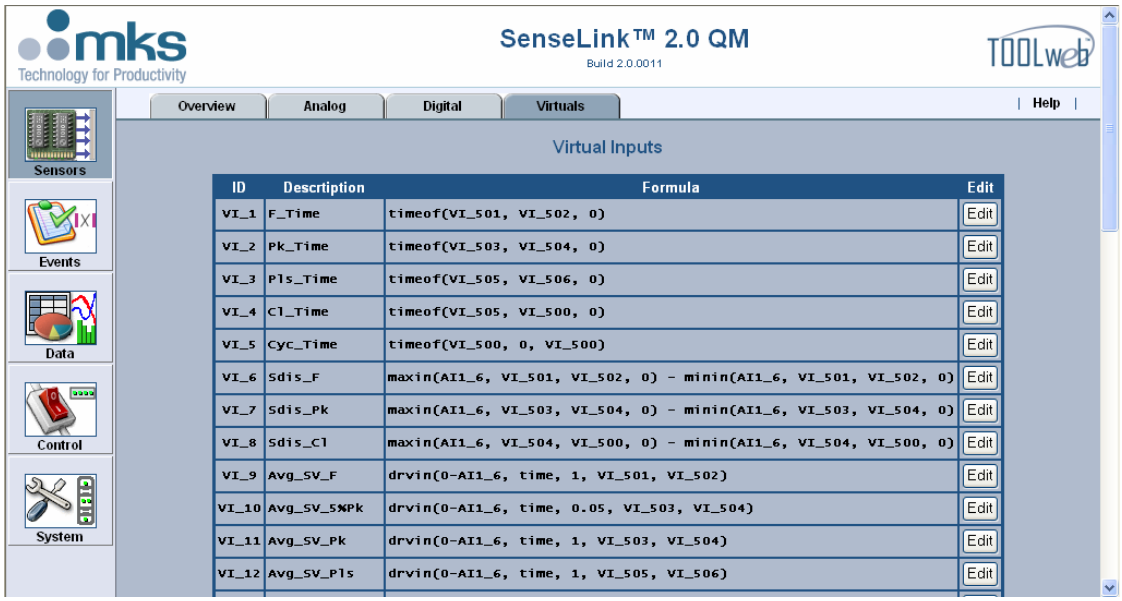
SenseLink™ 2.0 QM
Build 2.0.0011
Overview
Analog
Digital
Virtuals
Help
Sensors
Events
Data
Control
System
Virtual Inputs
ID Description Formula Edit
VI_1 F_Time timeof(VI_501, VI_502, 0) Edit
VI_2 Pk_Time timeof(VI_503, VI_504, 0) Edit
VI_3 Pls_Time timeof(VI_505, VI_506, 0) Edit
VI_4 Cl_Time timeof(VI_505, VI_500, 0) Edit
VI_5 Cyc_Time timeof(VI_500, 0, VI_500) Edit
VI_6 Sdis_F maxin(AI1_6, VI_501, VI_502, 0) - minin(AI1_6, VI_501, VI_502, 0) Edit
VI_7 Sdis_Pk maxin(AI1_6, VI_503, VI_504, 0) - minin(AI1_6, VI_503, VI_504, 0) Edit
VI_8 Sdis_Cl maxin(AI1_6, VI_504, VI_500, 0) - minin(AI1_6, VI_504, VI_500, 0) Edit
VI_9 Avg_SV_F drvin(0-AI1_6, time, 1, VI_501, VI_502) Edit
VI_10 Avg_SV_5%Pk drvin(0-AI1_6, time, 0.05, VI_503, VI_504) Edit
VI_11 Avg_SV_Pk drvin(0-AI1_6, time, 1, VI_503, VI_504) Edit
VI_12 Avg_SV_Pls drvin(0-AI1_6, time, 1, VI_505, VI_506) Edit

Figure 16 Virtual Inputs

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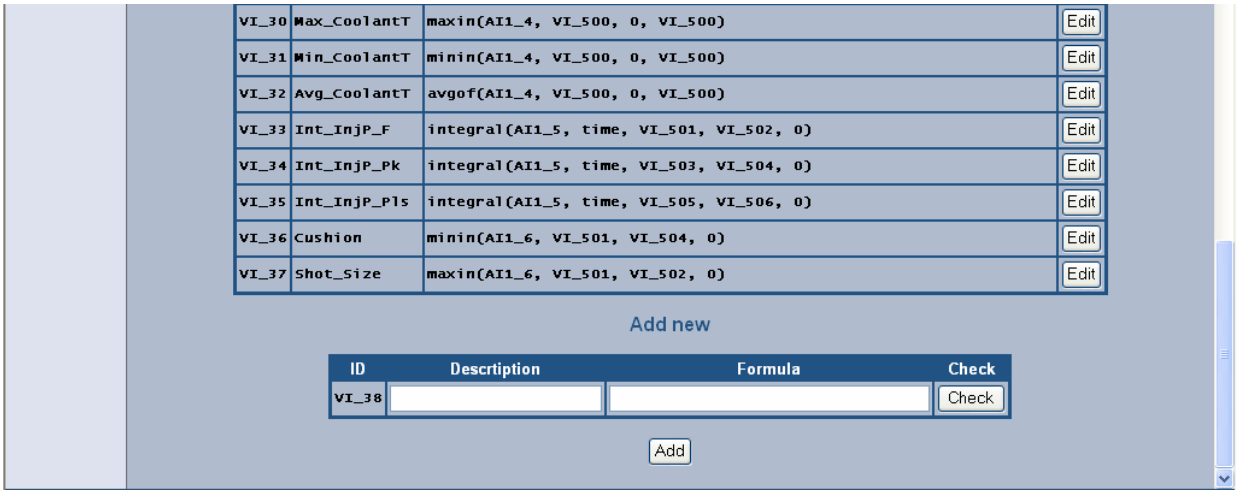
VI_30 Max_CoolantT maxin(AI1_4, VI_500, 0, VI_500) Edit
VI_31 Min_CoolantT minin(AI1_4, VI_500, 0, VI_500) Edit
VI_32 Avg_CoolantT avgof(AI1_4, VI_500, 0, VI_500) Edit
VI_33 Int_InjP_F integral(AI1_5, time, VI_501, VI_502, 0) Edit
VI_34 Int_InjP_Pk integral(AI1_5, time, VI_503, VI_504, 0) Edit
VI_35 Int_InjP_Pls integral(AI1_5, time, VI_505, VI_506, 0) Edit
VI_36 Cushion minin(AI1_6, VI_501, VI_504, 0) Edit
VI_37 Shot_Size maxin(AI1_6, VI_501, VI_502, 0) Edit
Add new
ID Description Formula Check
VI_38 Check
Add

Figure 17 Adding Virtuals

4.6 Events

Under the ***Events*** tab, process states such as process start and end can be created using Boolean expressions. Events can also be used in the virtual calculation to simplify the equations.

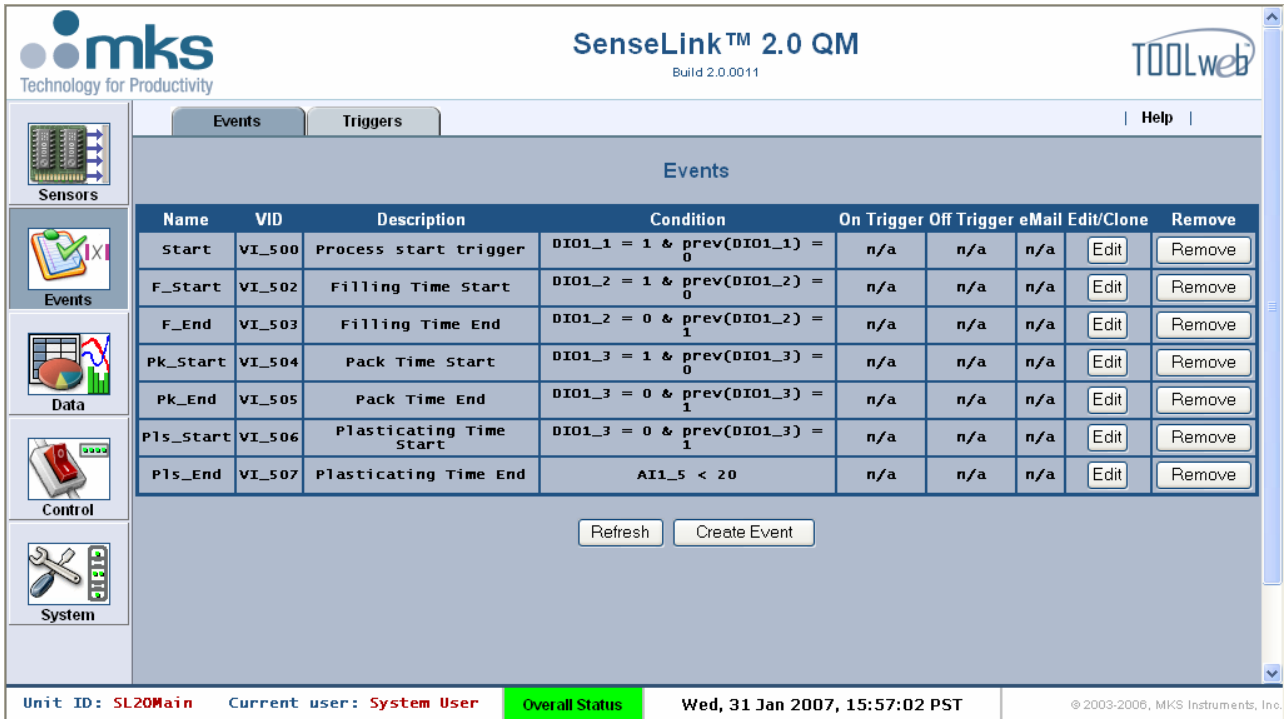
Technology for Productivity
SenseLink™ 2.0 QM
Build 2.0.0011
TOOLweb
Sensors
Events
Data
Control
System
Events
Triggers
Help
Events
Name VID Description Condition On Trigger Off Trigger eMail Edit/Clone Remove
Start VI_500 Process start trigger DIO1_1 = 1 & prev(DIO1_1) = 0 n/a n/a n/a Edit Remove
F_Start VI_502 Filling Time Start DIO1_2 = 1 & prev(DIO1_2) = 0 n/a n/a n/a Edit Remove
F_End VI_503 Filling Time End DIO1_2 = 0 & prev(DIO1_2) = 1 n/a n/a n/a Edit Remove
Pk_Start VI_504 Pack Time Start DIO1_3 = 1 & prev(DIO1_3) = 0 n/a n/a n/a Edit Remove
Pk_End VI_505 Pack Time End DIO1_3 = 0 & prev(DIO1_3) = 1 n/a n/a n/a Edit Remove
Pls_Start VI_506 Plasticating Time Start DIO1_3 = 0 & prev(DIO1_3) = 1 n/a n/a n/a Edit Remove
Pls_End VI_507 Plasticating Time End AI1_5 < 20 n/a n/a n/a Edit Remove
Refresh
Create Event
Unit ID: SL20Main
Current user: System User
Overall Status
Wed, 31 Jan 2007, 15:57:02 PST
© 2003-2006, MKS Instruments, Inc.

Figure 18 Process Events

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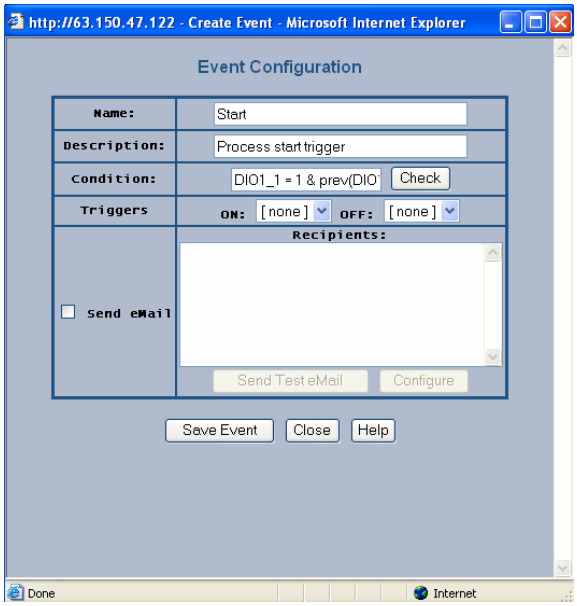

Figure 19 Configuring Events

4.7 Triggers

Create output functions or control sequences that can happen as result of the data analysis. For example, conveyers or robots can be setup to eliminate suspect parts.

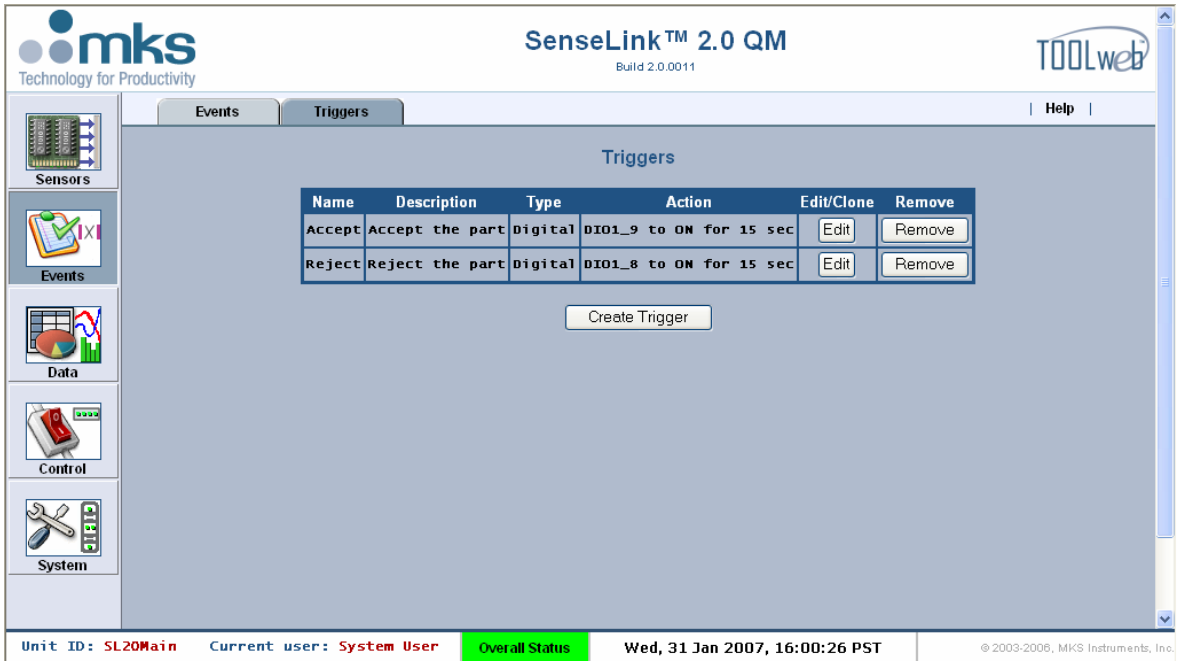

Figure 20 Cycle Triggers

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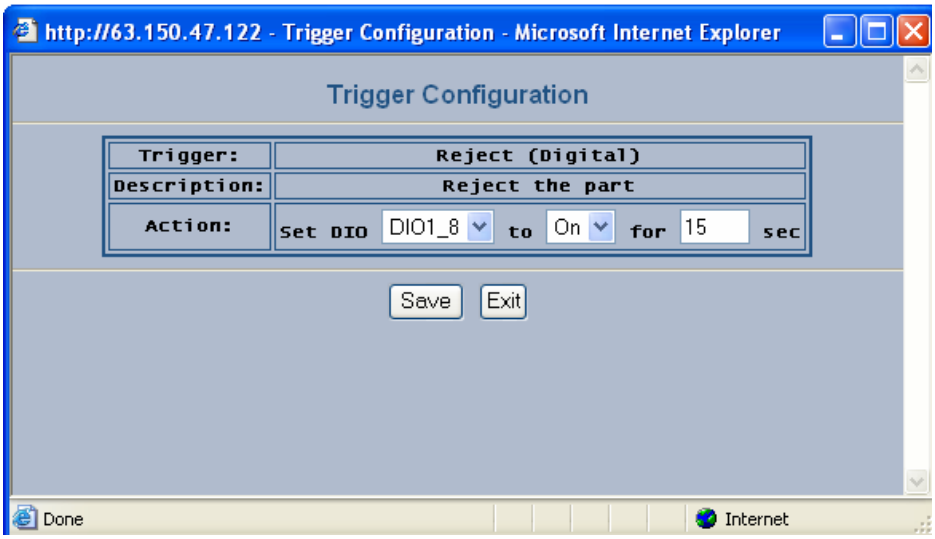

Figure 21 Editing Triggers

4.8 Collect

Under the ***Data/Traces*** tab, collection plans can be created which specify the data to collect, the data sampling rate, and the data publishing rate. By default the DataCP collection plan is setup as the modeling collection plan with only virtuals selected and the Test collection plan is setup for viewing of raw analog and digital signals.

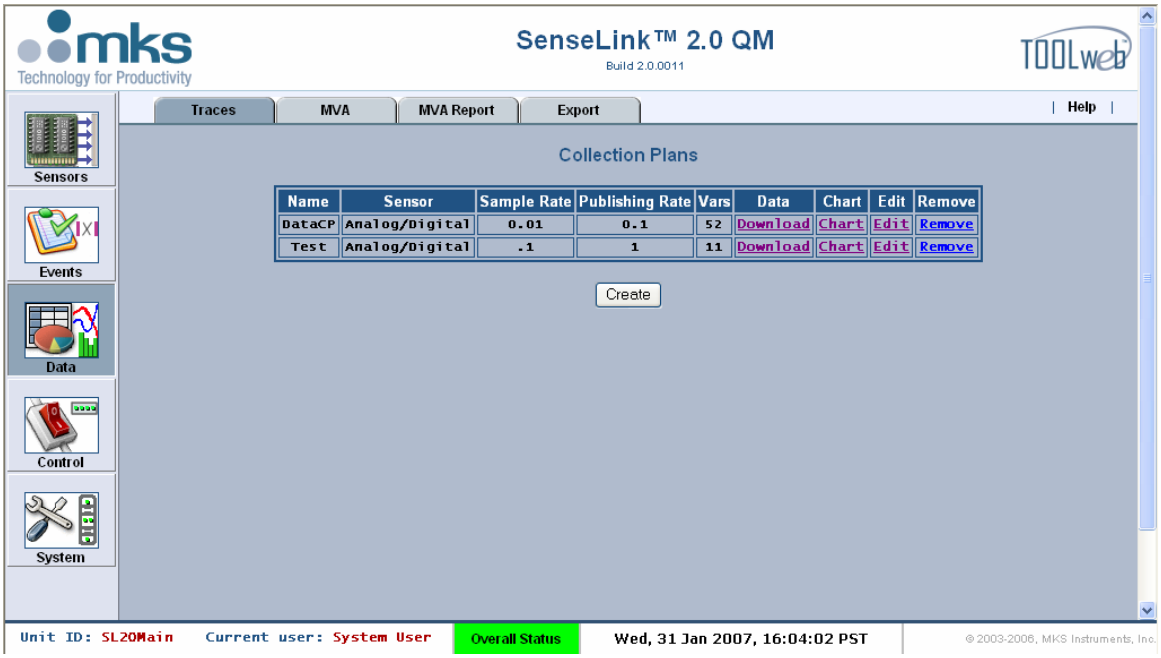

Figure 22 Data Collection Plans

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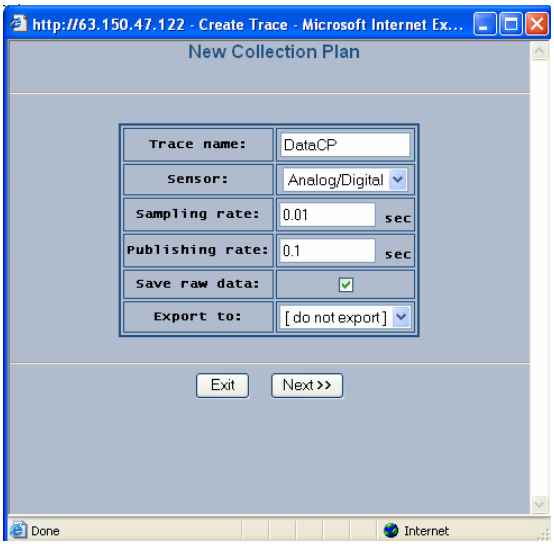

Figure 23 Editing Collection Plans

4.9 Running the DOE

1. Select the ***MVA Config*** page.
2. Ensure that the DataCP collection plan is selected before running the DOE.
3. Also be sure to select the event “Start”, as it is setup as mold open (cycle start and cycle end) for both Process Start and Process Stop.
4. Select the triggers for Accept and Reject and also for the Health DIO select the System OK digital output which by default is DIO1_10.
5. Then select ***Activate*** to put the changes in place.

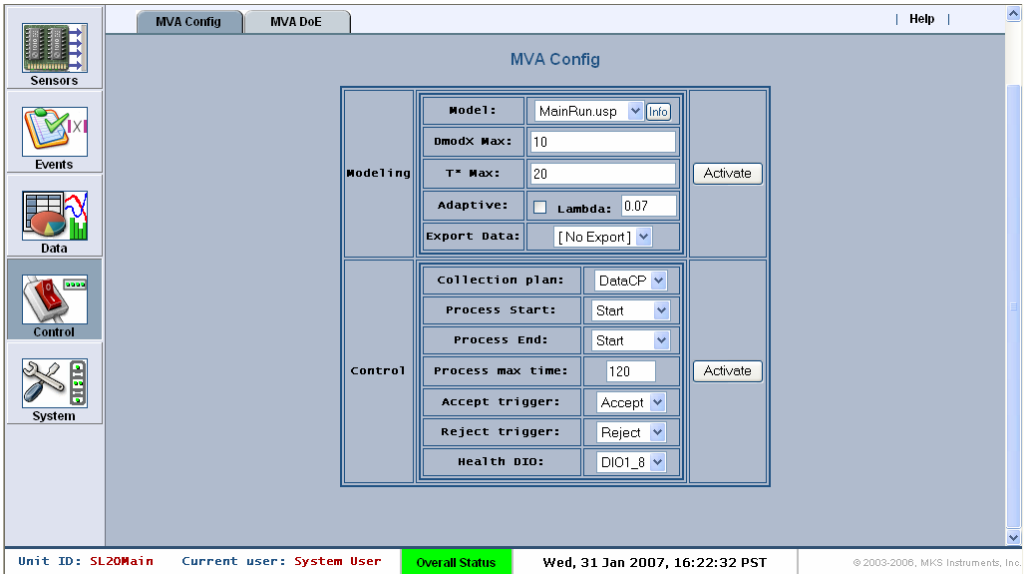

Figure 24 Setting up Data Collection to Run DOE

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6. To begin the DOE select ***MVA DoE*** and enter the name of the DOE and the amount of data collection time needed to run the DOE. Select ***Start***, data is now being collected which will be used to create the model. Select ***Stop*** to finish the DOE and store the data.

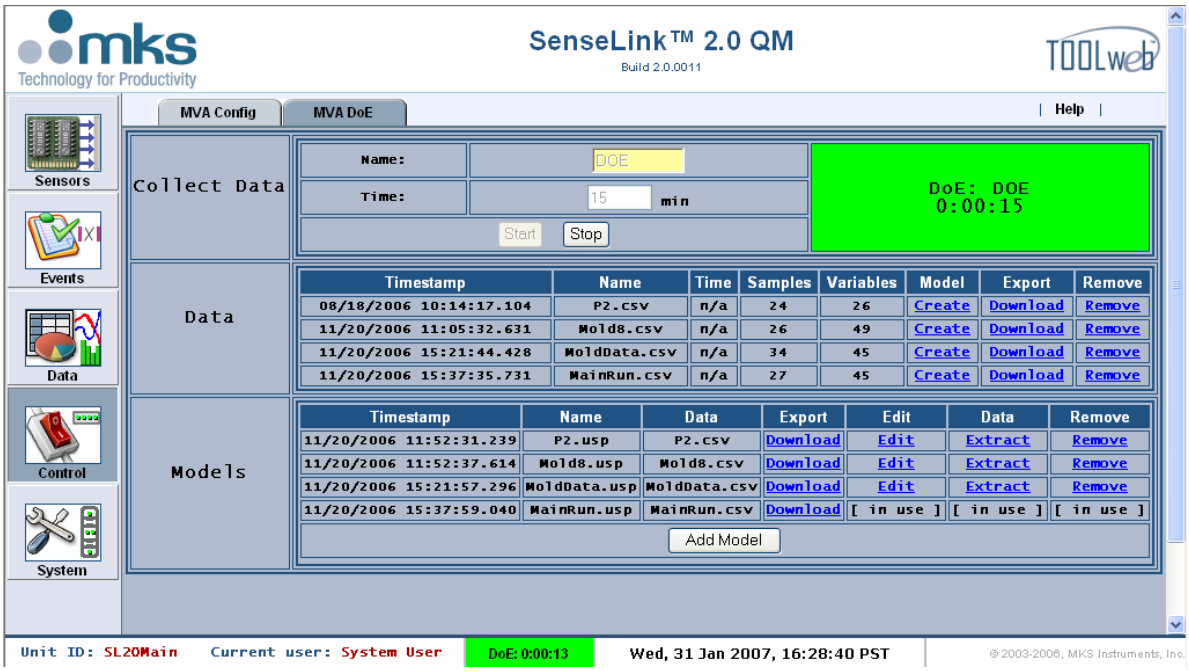
SenseLink™ 2.0 QM
Build 2.0.0011
Technology for Productivity
TOOLweb
MVA Config
MVA DoE
Help
Sensors
Events
Data
Control
System
Collect Data
Name:
DOE
Time:
15
min
Start
Stop
DoE: DOE
0:00:15
Data
Timestamp | Name | Time | Samples | Variables | Model | Export | Remove
08/18/2006 10:14:17.104 | P2.csv | n/a | 24 | 26 | Create | Download | Remove
11/20/2006 11:05:32.631 | Mold8.csv | n/a | 26 | 49 | Create | Download | Remove
11/20/2006 15:21:44.428 | MoldData.csv | n/a | 34 | 45 | Create | Download | Remove
11/20/2006 15:37:35.731 | MainRun.csv | n/a | 27 | 45 | Create | Download | Remove
Models
Timestamp | Name | Data | Export | Edit | Data | Remove
11/20/2006 11:52:31.239 | P2.usp | P2.csv | Download | Edit | Extract | Remove
11/20/2006 11:52:37.614 | Mold8.usp | Mold8.csv | Download | Edit | Extract | Remove
11/20/2006 15:21:57.296 | MoldData.usp | MoldData.csv | Download | Edit | Extract | Remove
11/20/2006 15:37:59.040 | MainRun.usp | MainRun.csv | Download | [in use] | [in use] | [in use]
Add Model
Unit ID: SL20Main
Current user: System User
DoE: 0:00:13
Wed, 31 Jan 2007, 16:28:40 PST
© 2003-2006, MKS Instruments, Inc.

Figure 25 Running the DOE

4.10 Creating and Editing Models

Creating a model can either be done offline through SIMCA P+ and uploaded into the SenseLink under the ***MVA DoE*** page or it can be created online within the SenseLink.

4.10.1 Creating Models Offline using SIMCA P+

Once the data from the DOE is stored in the data section shown above, select ***Download*** in the Export column and save the file. The file can then be imported into SIMCA P+ for analysis and individual parts or runs can be excluded from the data set if necessary. The data should be analyzed with only X-variables to create a Principal Component Analysis (PCA) model. This model should then be saved as an .usp file and can be imported into the SenseLink. Select ***Add Model*** and browse to the saved model file and select ***Upload***. The model is now available for use in the SenseLink QM and will show up in the Models section shown above.

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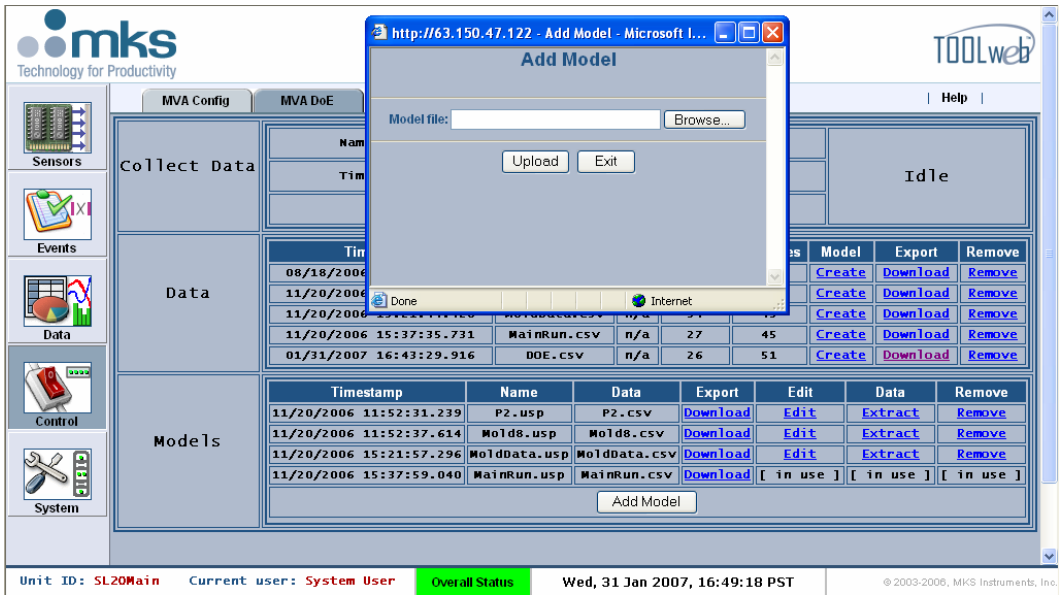

Figure 26 Importing Model from SIMCA P+

4.10.2 Creating Models Online through SenseLink

Once the data from the DOE is stored in the Data section shown below, select ***Create*** to create the model. A new window will open; be sure that Data Features Only is selected and select ***Create*** and close when the model is successfully created. The model will then be created and will be displayed in the Models section shown below.

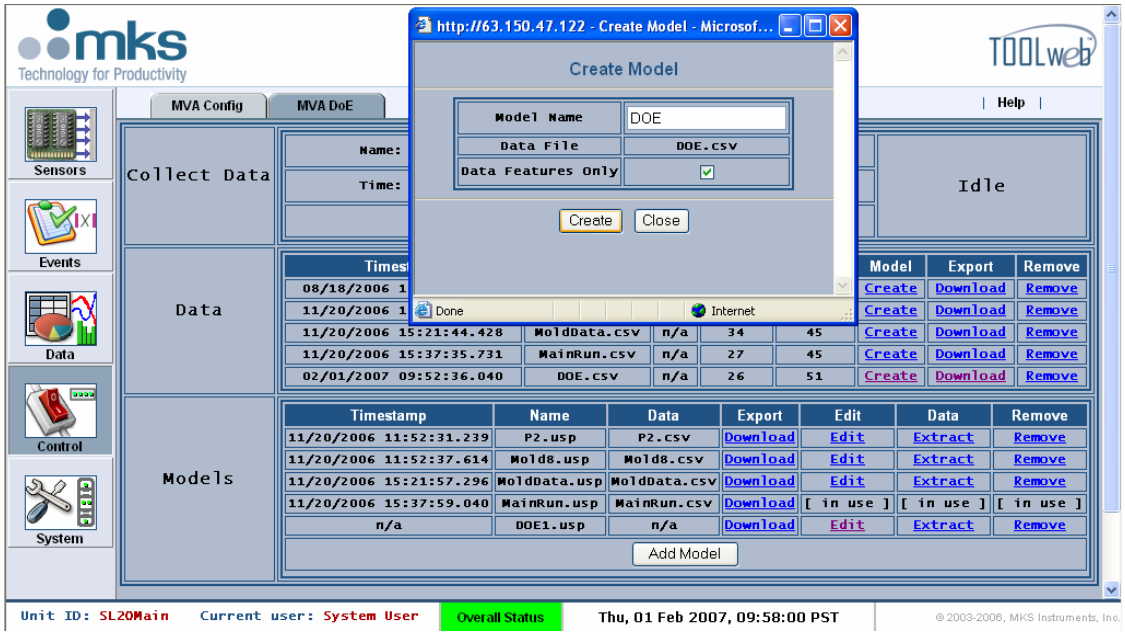

Figure 27 Creating Model Online Through SenseLink

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4.10.3 Editing Models

Select ***Edit Model*** to see the first and second component scatter plot and view outliers. From here you can remove outliers and rebuild the model.

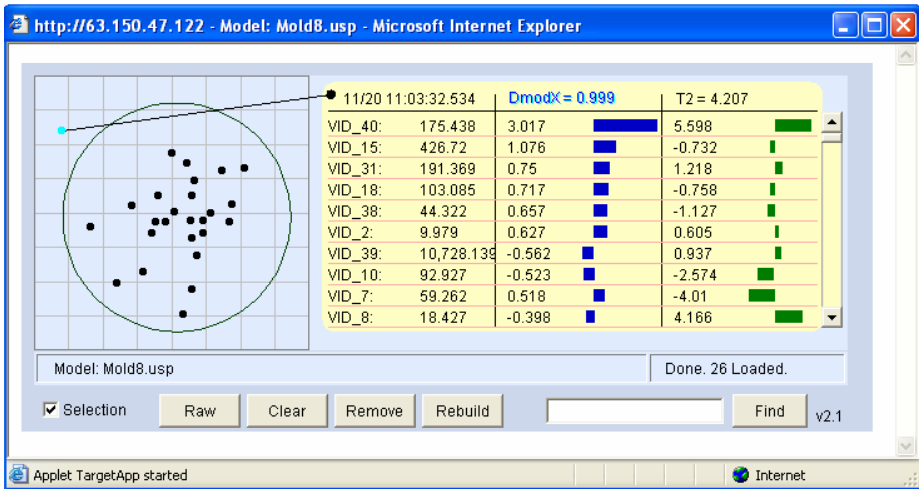

Figure 28 Editing and Rebuilding Model

4.11 Running Models

Setting up the model to run can be done by selecting ***MVA Config***. From here select the drop down arrow under Models and select the appropriate model. Before selecting Activate, select ***Copy Limits*** to set the DModX and T^2 limits of the selected model. Also, Adaptive should not be check and the system should be setup to not export data. Now select ***Activate*** and the model is now in place. The first two or three shots will be automatically rejected by the system before the new model is fully activated. Any new shots are now being compared to the activated model.

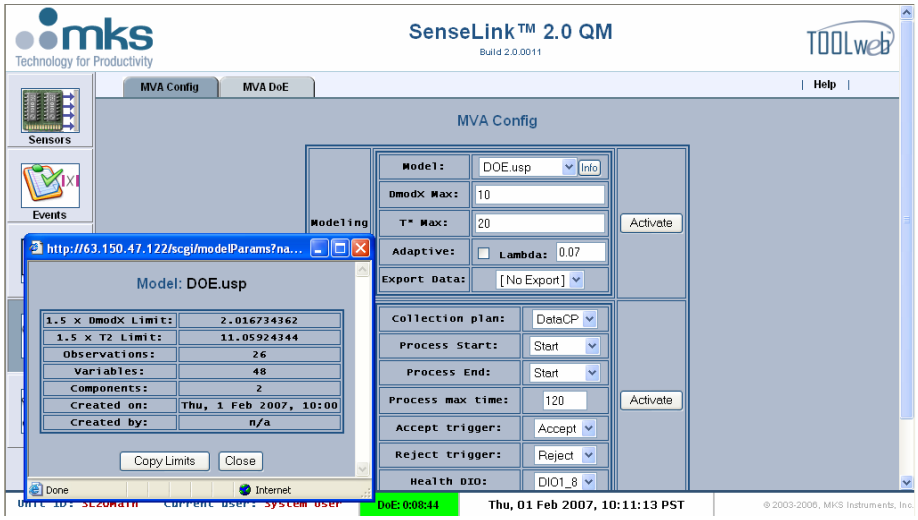

Figure 29 Model Setup with DOE Results

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5 SenseLink Hardware

5.1 Hardware Description

The SenseLink is a compact, Linux controller with integrated I/O and peripherals. The CPU will have Linux kernel 2.4.x. All required kernel drivers are preloaded to support current hardware requirements.

There are 5 hardware packages, each to accommodate the number of I/O slots (0-4) Each I/O card to have a D-sub 37 connector, top and bottom. Each cards connectors to be in the same location, so enclosure cutouts are the same for a DIDO or AIAO card.

The front of the SenseLink provides all operators interface and status indicators. The figure below describes the features on the front panel. These items include I/O indicators, fuses, IP address switches, and diagnostic ports.

The following mechanical drawing is a typical 2 expansion slot model.

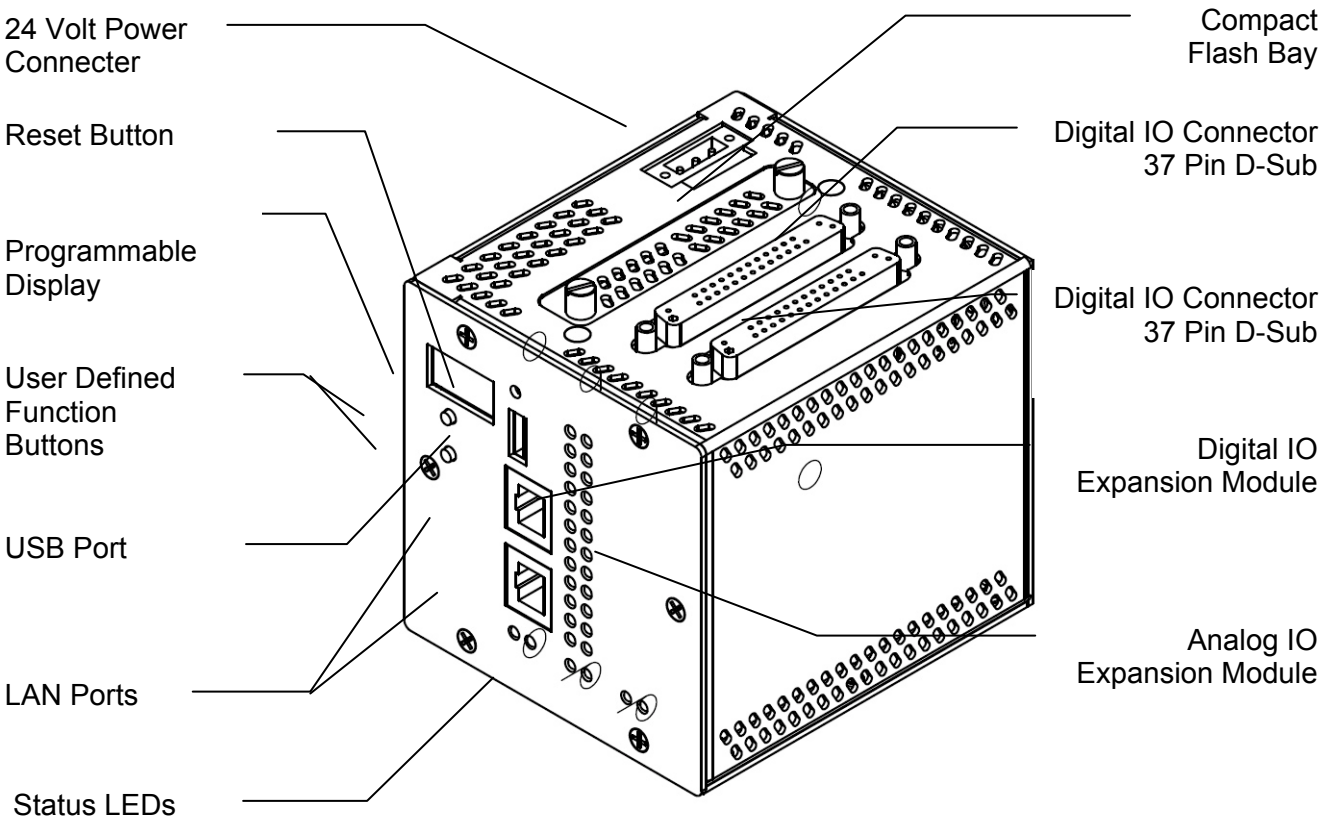

Figure 30 SenseLink Hardware Description

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5.2 Mechanical Description

The following mechanical drawing describes a typical 2 slot configuration. Additional slots will cause the unit to be wider but will not change height or depth. Addition mechanical information for other configurations can be obtained through your local MKS representative

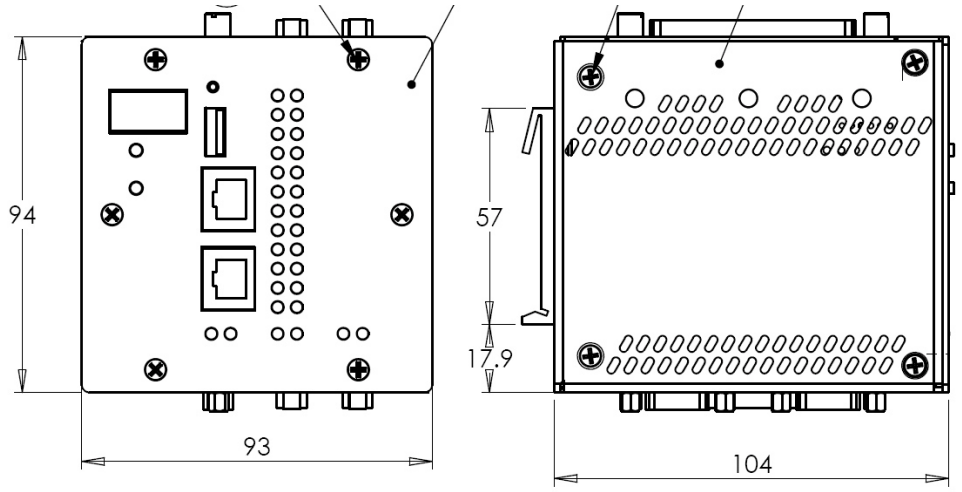

Figure 31 Mechanical Description

Note **ALL DIMENSIONS ARE METRIC**

5.3 Installation

The SenseLink mounts on a standard 35mm DIN rail system. Make sure there is sufficient side clearance for ventilation, to maintain an ambient operating temperature of 0°C to 50°C.

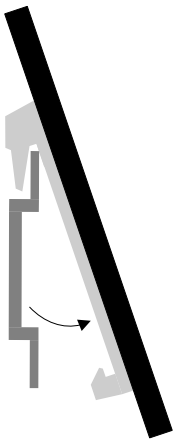

Figure 32 SenseLink DIN Rail Mounting

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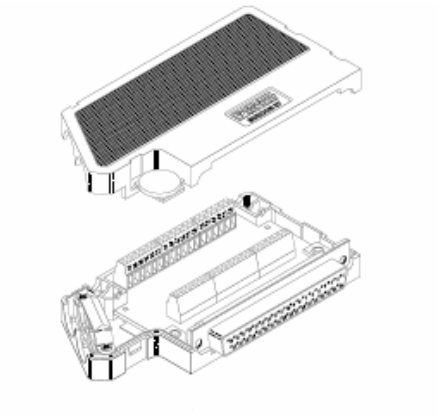
5.4 Wiring and Hardware Configuration

Ethernet and I/O cables are available from a variety of industrial sources. See table below for orderable I/O mating connectors. Example mating connector for the SenseLink IO is provided in Table 4.

Table 4 Mating IO Connector Information

Description	MFG	Part Number
37-pin D-SUB with Shell (Terminal Block Connections)	Phoenix	2300986



Caution **In order to guarantee proper operation and prevent damage to the product insure that the chasis ground is properly attached for the application.**

Warning **Follow all applicable electrical codes when mounting and wiring any electrical device.**

5.4.1 Power Supply Wiring

Connect an external 18-30 VDC power supply to the 3-terminal Power Connector. The connector should be wired according to the labeling on the SenseLink.

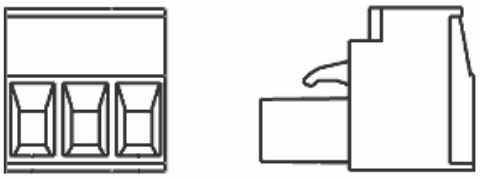


Figure 33 Power Terminal Block Wiring

Table 5 Power Terminal Block Wiring

Pin	Signal
1	18-30 VDC
2	Chassis GND
3	GND

The manufacturer and ordering part number for the SenseLink power terminal block connector is described in Table 6.

Table 6 Terminal Block Information

Description	MFG	Part Number
3-pin Terminal Block	Weidmuller	1625620000

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5.4.2 Analog I/O Wiring

The SenseLink QM analog expansion board has two D-Sub 37 connectors used to access the I/O points. Each I/O card type has unique pin assignments; the assignments for the analog card are shown in the following figures.

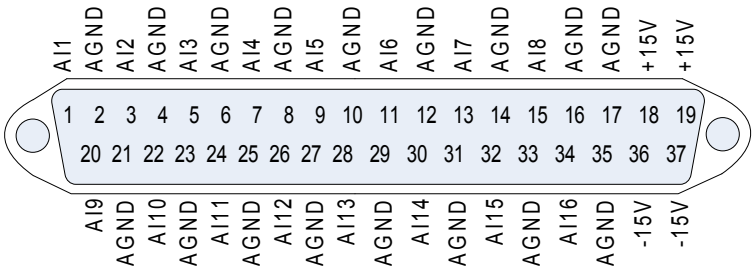
AI1 AGND AI2 AGND AI3 AGND AI4 AGND AI5 AGND AI6 AGND AI7 AGND AI8 AGND AGND +15V +15V
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
AI9 AGND AI10 AGND AI11 AGND AI12 AGND AI13 AGND AI14 AGND AI15 AGND AI16 AGND -15V -15V

Figure 34 Analog Inputs - Differential Mode

Top Side Connector

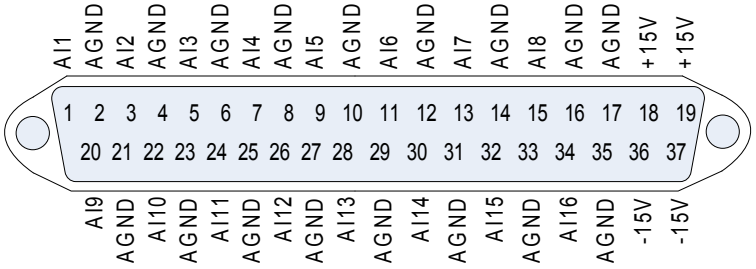
AI1 AGND AI2 AGND AI3 AGND AI4 AGND AI5 AGND AI6 AGND AI7 AGND AI8 AGND AGND +15V +15V
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
AI9 AGND AI10 AGND AI11 AGND AI12 AGND AI13 AGND AI14 AGND AI15 AGND AI16 AGND -15V -15V

Figure 35 Analog Inputs - Single Ended Mode

Top Side Connector

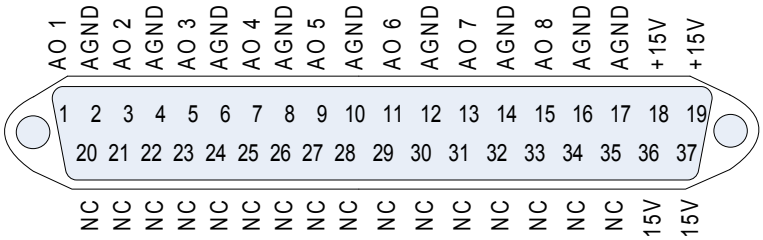
AO 1 AGND AO 2 AGND AO 3 AGND AO 4 AGND AO 5 AGND AO 6 AGND AO 7 AGND AO 8 AGND AGND +15V +15V
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
NC NC NC NC NC NC NC NC NC NC NC NC NC NC NC NC 15V 15V

Figure 36 Analog Outputs

Bottom Side Connector

Note **ALL ANALOG POWER COMES FROM AN INTERNAL POWER CONVERTER. EXTERNAL PINS FOR +/- 15 VOLTS SHOULD BE USED AS REFERENCE ONLY. SUPPLIES HAVE LIMITED POWER AND SHOULD NOT BE USED TO DRIVE EXTERNAL LOADS.**

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5.4.3 Digital I/O Wiring

The SenseLink digital expansion board has two D-Sub 37 connectors used to access the I/O points. The +24V power must be supplied by an external source via these connectors. Each I/O card type has unique pin assignments; the assignments for the digital card are shown in the following figures. All the 24 GNDs are one net.

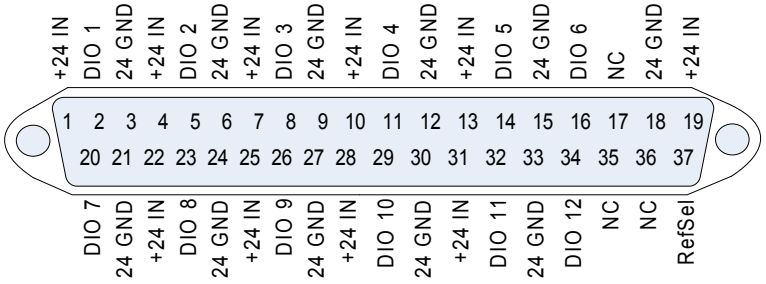

Figure 37 Digital Top Side Connector

Table 7 Source/Sink Select for Digital Top Connector

Sink/Source Select	
Source	**Short Pin 18 to 37**
Sink	**Short Pin 19 to 37**

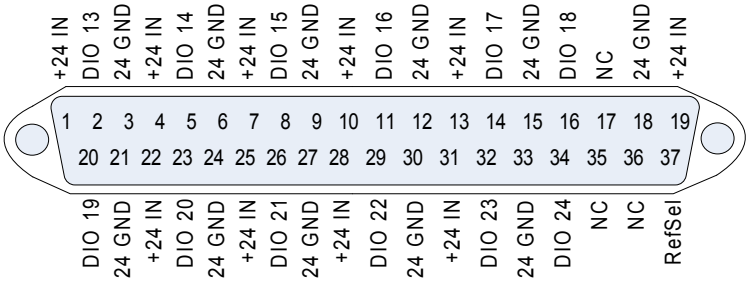

Figure 38 Digital Bottom Side Connector

Table 8 Source/Sink Select for Digital Bottom Connector

Sink/Source Select	
Source	**Short Pin 18 to 37**
Sink	**Short Pin 19 to 37**

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5.4.4 Combo I/O Wiring

The Combo I/O Expansion Card has two 37-pin D-Sub connectors used to access the I/O points. The +24V power must be supplied by an external source via these connectors. The +/- 15V power is supplied by an internal converter. The pin assignments are shown in the following tables. All the 24 GNDs are one net.

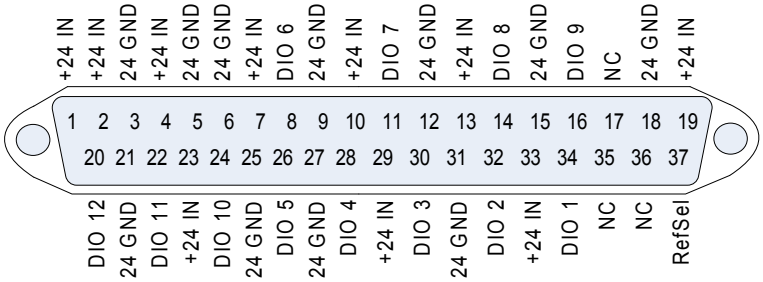

Figure 39 Combo Top Side Connector

Table 9 Source/Sink Select for Combo Top Connector

Sink/Source Select	
Source	**Short Pin 18 to 37**
Sink	**Short Pin 19 to 37**

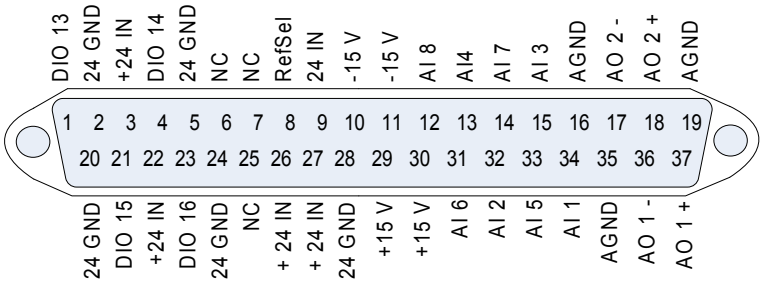

Figure 40 Combo Bottom Side Connector

Table 10 Source/Sink Select for Combo Bottom Connector

Sink/Source Select	
Source	**Short Pin 28 to 8**
Sink	**Short Pin 27 to 8**

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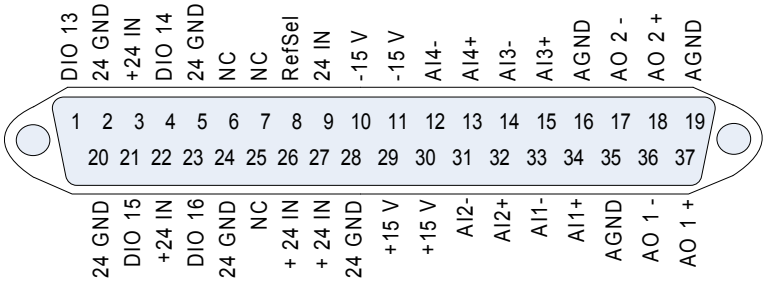

Figure 41 Combo Bottom Side Connector (Differential)

Table 11 Source/Sink Select for Combo Bottom Connector

Sink/Source Select	
Source	**Short Pin 28 to 8**
Sink	**Short Pin 27 to 8**

Note

ALL ANALOG POWER COMES FROM AN INTERNAL POWER CONVERTER. EXTERNAL PINS FOR +/- 15 VOLTS SHOULD BE USED AS REFERENCE ONLY. SUPPLIES HAVE LIMITED POWER AND SHOULD NOT BE USED TO DRIVE EXTERNAL LOADS

5.5 Digital Inputs

Digital I/O can be ordered as either sinking (active low) or sourcing (active high) I/O. Each input circuit includes an indicator LED in series with the detection opto-coupler. The opto-coupler isolates the processor from the inputs. The inputs require 1.5mA in order to turn on.

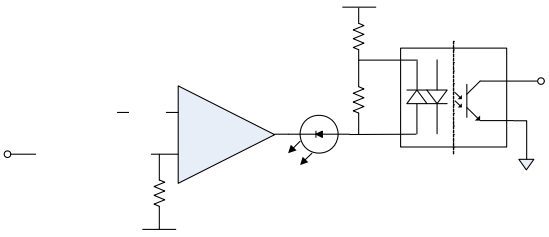

Figure 42 Sinking Input

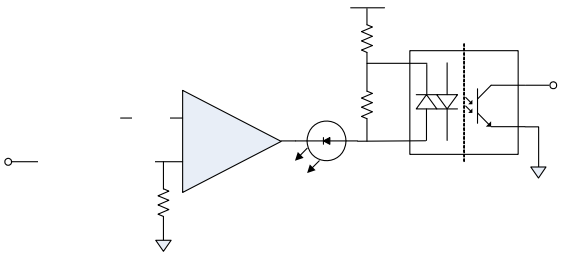

Figure 43 Sourcing Input

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5.6 Digital Input Interface Example

Below is an example of how to use the digital input interface for both the sinking and sourcing hardware configurations. The digital I/O circuitry is powered from an external +24-volt power source via the I/O connector.

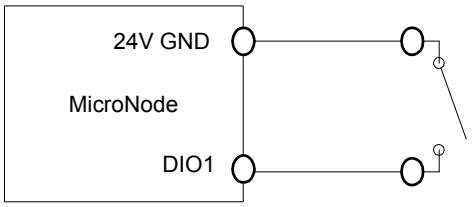

Figure 44 Sinking Input

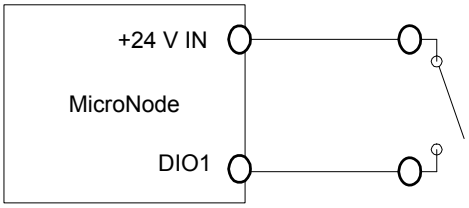

Figure 45 Sourcing Input

5.7 Digital Outputs

The individual outputs will support up to a 200 mA load per channel. Each output is thermally protected against short-circuiting (500 mA typically) and includes under voltage protection. The output Fault State is accessible through software. External Schottky diodes are provided for output transient protection and each I/O point is protected with a self-resetting poly fuse rated for 500 mA. Outputs default to the OFF condition during power up and processor reset conditions. The figure below shows the output circuitry.

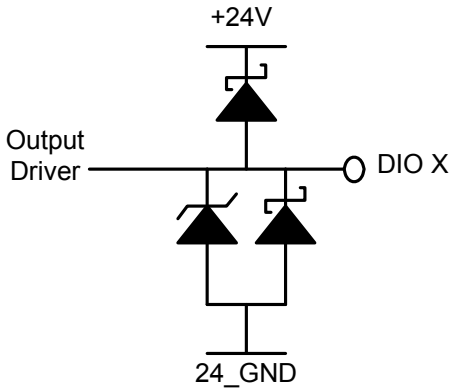

Figure 46 Digital Output

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5.8 Digital Output Interface Example

Below is an example of how to interface with the digital outputs for both the sinking and sourcing hardware configurations. The digital I/O circuitry is again powered from an external +24-volt power source via the I/O connector.

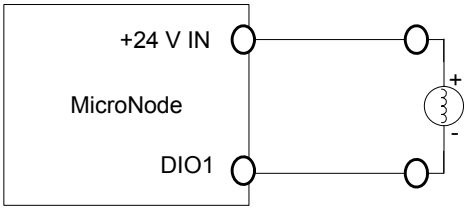

Figure 47 Sinking Output

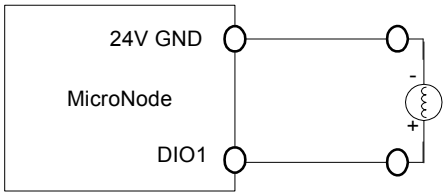

Figure 48 Sourcing Output

5.9 Analog Inputs

The analog inputs are coupled directly to the processor and are implemented using 12 bit A/D converters. The analog input range is –10V to +10V.

All analog circuitry is powered from an internal ±15 Vdc power source. The +15 V and -15 V power is protected with a self-resetting poly fuse rated at 100 mA.

Table 12 Analog Voltage Conversion

Conversion Table	
10 V	0x1FFF
5 V	0x0FFF
0.0012 V	0x0001
0 V	0x0000
-0.0012 V	0xFFFF
-5 V	0x2FFF
-10 V	0x2000

Table 13 Analog Description

Card Type	Number of Inputs	Type
Analog Expansion Card	16	Single ended inputs
Combo Expansion Card	8	Single ended inputs that can also be connected in pairs to create differential inputs. Particular pairs must be used (input 1-5, 2-6, 3-7, 4-8) if a differential input is required.

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5.10 Analog Outputs

The analog outputs are implemented using 12 bit D/A's with a –10V to +10V output range. The output drivers are capable of driving 2 Kohm (5 mA) output loads. Analog outputs default to 0 volts during power up and processor reset conditions.

Table 14 Analog Voltage Conversion

Conversion Table	
10 V	0x0FFF
5 V	0x0BFF
0 V	0x07FF
-5 V	0x03FF
-10 V	0x0000

Table 15 Analog Description

Card Type	Number of Outputs	Type
Analog Expansion Card	8	Single ended outputs
Combo Expansion Card	2	Differential outputs

5.11 Serial Port Connections

The SenseLink contains four total serial communication ports. Connector is standard D-Sub 9 pin male. COM1 and COM2 are RS232 only. COM3 and COM4 are RS232/RS485 Software selectable.

Table 16 Serial Port Connections

Pin	Signal – RS232
1	
2	Rx
3	Tx
4	jmp
5	GND
6	jmp
7	
8	
9	

Pin	Signal – RS485HD
1	
2	Tx
3	Tx
4	*jmp*
5	GND
6	*jmp*
7	Rx
8	Rx
9	

Pin	Signal – RS485FD
1	
2	Rx-
3	Tx-
4	*jmp*
5	GND
6	*jmp*
7	Tx+
8	Rx+
9	

For RS485 half-duplex mode, pin2, pin3 (Tx) need to be tied together. Pin7, pin8 (Rx) also need to be tied together.

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5.12 Network Configuration

The SenseLink has 2 LAN 100/10 BaseT Ethernet ports. The following are factory-default ethernet settings.

Table 17 LAN 1 Configuration

Parameter	SenseLink Setting
IP-Address of eth0	DHCP
Subnet Mask	None
Default Gateway	None

Table 18 LAN 2 Configuration

Parameter	SenseLink Setting
IP-Address of eth1	192.168.1.2
Subnet Mask	255.255.255.0
Default Gateway	None

Reading or changing the network settings of an unknown unit is achieved by connecting via a serial terminal session.

5.13 Weidmuller Thermocouple Module

This section provides the basic configuration and setup for the Weidmuller Thermocouple Module used with the SenseLink hardware. This document outlines the configuration of the thermocouple, wiring and installation, and configuring the analog input channel formula.

5.13.1 Configuring the Weidmuller Thermocouple

The Weidmuller Thermocouple Module is configured via two, eight position dip switches. The dip switches are accessed by removing the shell of the Thermo Select Module

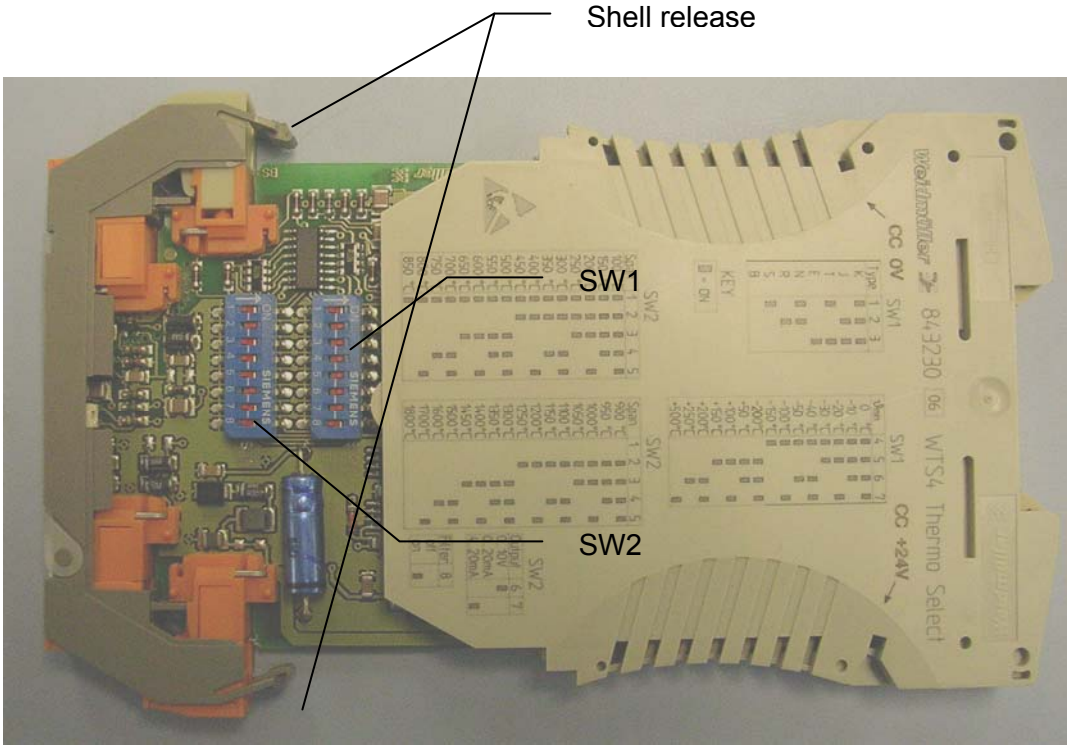

Figure 49 Weidmuller Thermocouple Module

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The following describes the configuration for use with the SenseLink:

Table 19 Switch 1

Pin	Switch Position	SW1 Description
1	OFF	Switches 1,2,3 are used to describe the type of thermocouple being used, This application is for a Type J.
2	ON	
3	ON	
4	ON	Switches 4,5,6,7 are used to set the minimum temperature. This application used 0 degrees.
5	ON	
6	ON	
7	ON	
8	ON	Has no function

Table 20 Switch 2

Pin	Switch Position	SW2 Description
1	OFF	Switches 1-5 are used to set the temperature span. This application will use 1250 degrees.
2	ON	
3	OFF	
4	OFF	
5	OFF	
6	ON	Switched 6 and 7 are used to set the output mode. This application used 0-10 volts
7	OFF	
8	OFF	Switch 8 is to enable the filter. The filter will be disabled for this application as it would have a 6 second delay if enabled.

5.13.2 Wiring and installation

Wiring the thermocouple into the thermocouple module is done by connecting the positive lead to pin 1 and the negative lead to pin 3.

Connecting the supply to the thermocouple module is done by connecting 24 volts to pin 7 and connecting the common to pin 8.

Connecting the thermocouple to the SenseLink is done by connecting pin 6 of the thermocouple module to the AIN+ channel of the SenseLink. The AIN- of the SenseLink should connect to the 24 volt common used to power the thermocouple module.

Table 21 Weidmuller Thermocouple Pinout

Pin	Description
1	Thermocouple Positive Input
3	Thermocouple Negative Input
5	Do not Connect
6	Temperature Output 0-10 Volts
7	24 Volt Supply
8	24 Volt Common

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5.13.3 Calibrating Thermocouples

Setting up the analog inputs for the temperatures requires scaling the inputs so that they represent actual data values from the molding machine. First, name the signal. Adding the scale is accomplished by clicking on the corresponding scale for the channel indicated after you select ***Edit Inputs***.

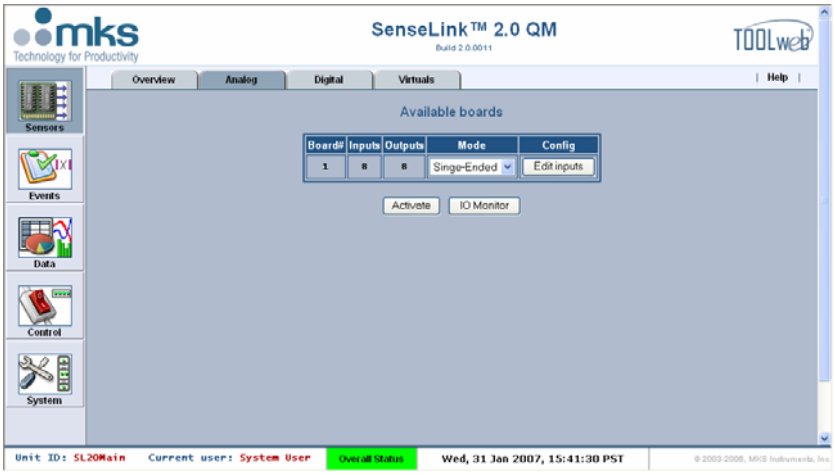

Figure 50 Analog Tab

Select ***n/a*** under Scaling will open the Channel Configuration Wizard window. Select formula and click next.

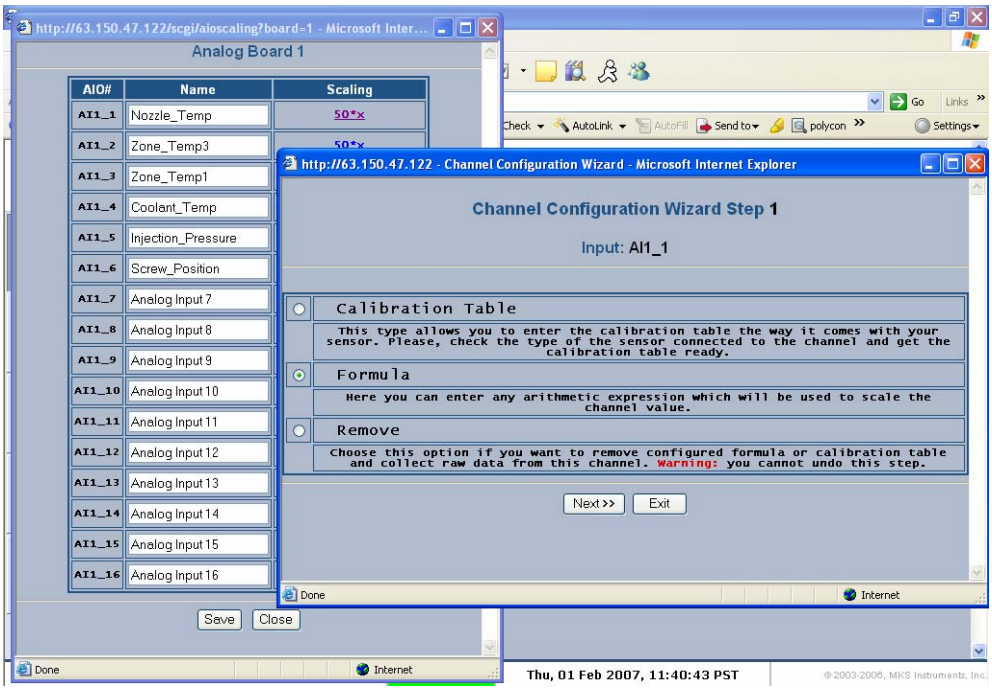
Analog Board 1
AIO#
Name
Scaling
AI1_1 Nozzle_Temp 50*x
AI1_2 Zone_Temp3 50*x
AI1_3 Zone_Temp1
AI1_4 Coolant_Temp
AI1_5 Injection_Pressure
AI1_6 Screw_Position
AI1_7 Analog Input 7
AI1_8 Analog Input 8
AI1_9 Analog Input 9
AI1_10 Analog Input 10
AI1_11 Analog Input 11
AI1_12 Analog Input 12
AI1_13 Analog Input 13
AI1_14 Analog Input 14
AI1_15 Analog Input 15
AI1_16 Analog Input 16
Save
Close
http://63.150.47.122 - Channel Configuration Wizard - Microsoft Internet Explorer
Channel Configuration Wizard Step 1
Input: AI1_1
Calibration Table
This type allows you to enter the calibration table the way it comes with your sensor. Please, check the type of the sensor connected to the channel and get the calibration table ready.
Formula
Here you can enter any arithmetic expression which will be used to scale the channel value.
Remove
Choose this option if you want to remove configured formula or calibration table and collect raw data from this channel. Warning: you cannot undo this step.
Next>>
Exit
Thu, 01 Feb 2007, 11:40:43 PST

Figure 51 Scaling window

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Calibrating the temperature inputs are dependent on the range the thermocouple module was set to. Various examples of temperature ranges along with the corresponding equations are shown in the table below. Converting from °C to °F is done by multiplying by 1.8 and adding 32.
Example equation: ((50*x)*1.8)+32

Table 22 Calibration Equations for Various Temperature Ranges

Temperature Range (°C)	Corresponding Equation (°C)
0 – 500	50*x
0 – 300	30*x
100 – 300	(20*x)+100
100 - 500	(40*x) + 100
150 - 300	(15*x) + 150
150 - 350	(20*x) + 150

Once you select ***Formula*** from Figure 51, shown above, the following window is displayed. The equations above can be copied and pasted directly into this window.

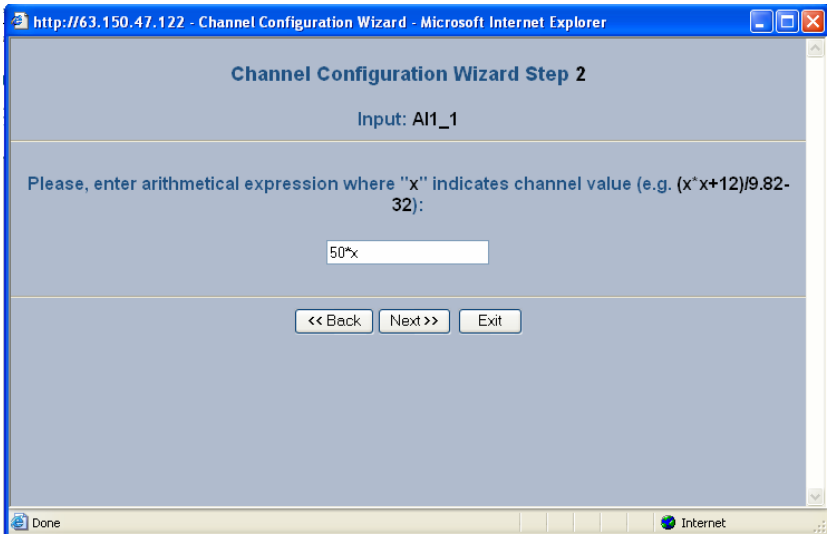

Figure 52 Calibration Formula

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6 SenseLink™ QM User Interface

The SenseLink user interface is web based. You can access it by simply browsing to the IP-Address of the SenseLink™.

Note Microsoft Internet Explorer 5.0.1 or higher is required. Microsoft Internet Explorer versions less than 5.5 may not function as expected due to limitations of the browser.

The user interface is divided into five main tabs:

- **Sensors**
  Allows the user to change the settings of the analog, digital, and virtual inputs
- **Events**
  Allows the user to create any events or triggers
- **Data**
  Allows the user to observe, download, and export process data
- **Control**
  Allows the user to create collection plans, run DOE's, and create and modify the model
- **System**
  Allows the user to change the basic time and network settings, modify users, and to upload software updates

Additional tabs may be implemented for application specific requirements. If additional functionality is required, work with MKS to determine feasibility. Application specific functionality will be provided in an addendum to this manual.

6.1 Sensors Overview

The sensors overview tab displays each of the analog and digital cards that are configured with the SenseLink.

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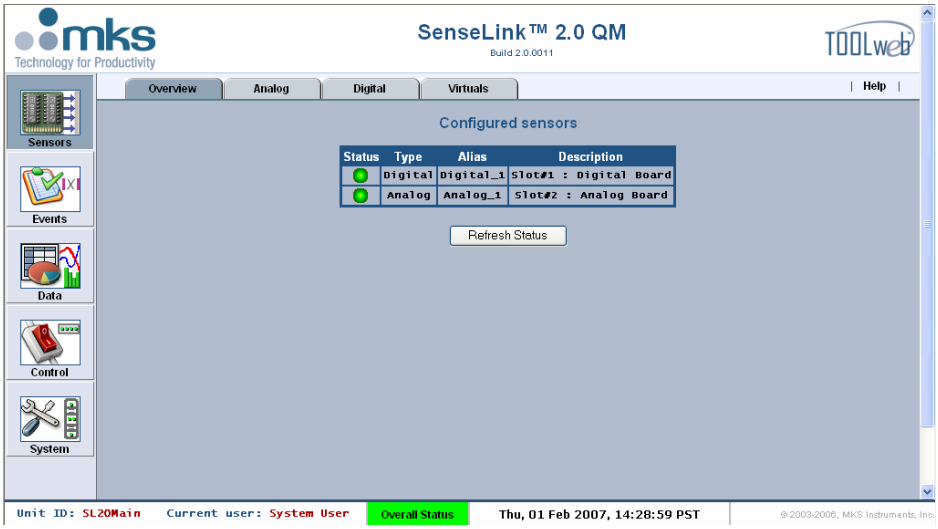

Figure 53 Sensors Overview

6.1.1 Analog Channels

Select the ***Analog*** tab to create and edit the analog signals.

6.1.1.1 Changing the Card Type

To change the analog board to Single-Ended or Differential mode click on the drop down arrow and select the mode to match the card type and select ***Activate***.

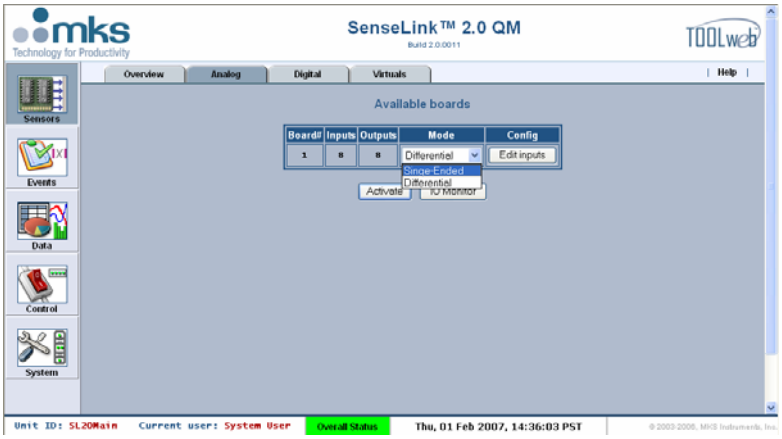

Figure 54 Selecting Analog Boards

6.1.1.2 Changing the Name of a Channel

To change the name of a channel, simply edit the appropriate field. The changes will become active after pressing the ***Save*** button. The ***Activate*** button must then be selected to submit the change.

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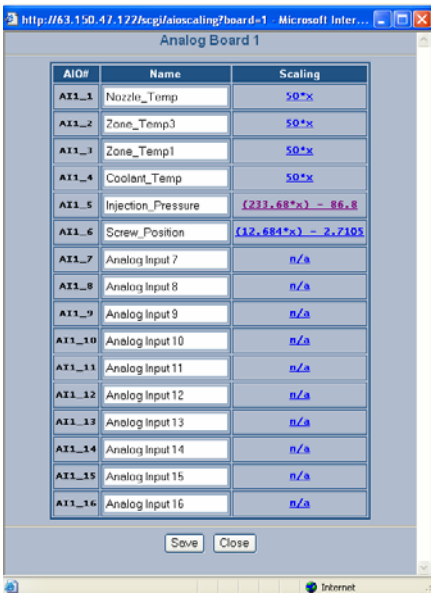

Figure 55 Configuring Analog Signals

6.1.1.3 Changing the Scaling of a Channel

To change the scaling of a channel, click on the link in the column: ***Scale***. A new window displays:

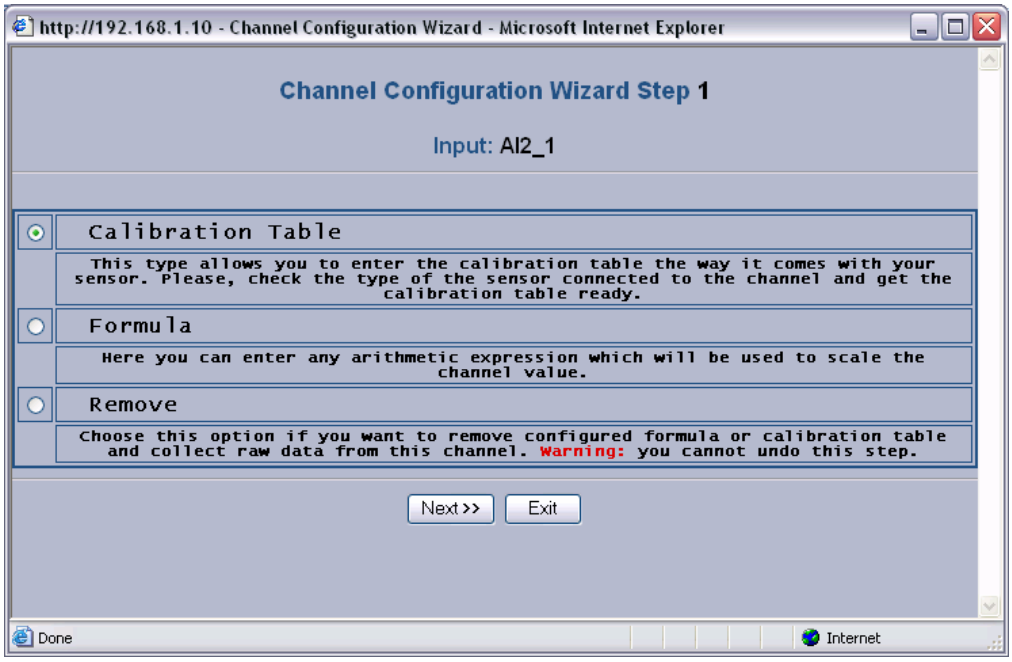
http://192.168.1.10 - Channel Configuration Wizard - Microsoft Internet Explorer
Channel Configuration Wizard Step 1
Input: AI2_1
Calibration Table
This type allows you to enter the calibration table the way it comes with your sensor. Please, check the type of the sensor connected to the channel and get the calibration table ready.
Formula
Here you can enter any arithmetic expression which will be used to scale the channel value.
Remove
Choose this option if you want to remove configured formula or calibration table and collect raw data from this channel. Warning: you cannot undo this step.
Next >>
Exit
Done
Internet

Figure 56 Scaling Analog Signals

You can select to:

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- Enter a calibration table manually
- Enter the calibration via a formula
- Remove a calibration from a channel

6.1.1.4 Enter Calibration via Table

This option allows you to enter the calibration table and test it.
The format of the calibration table is: Input Value=Output Value, where the input value is the raw voltage data and the output value is the calibrated value. It is important that a maximum and minimum value for the signal is used when using the calibration table.

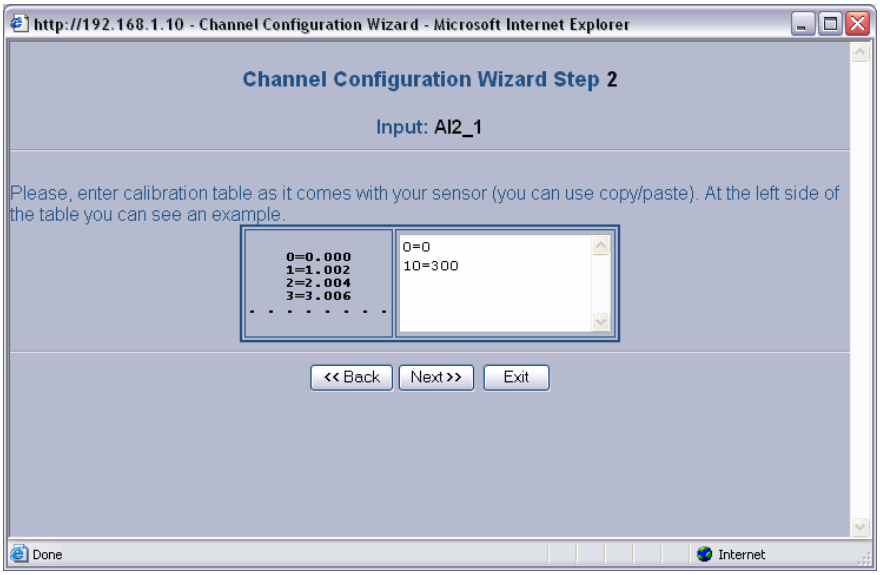

Figure 57 Creating Analog Calibration Tables

In the next step of the channel configuration, you can test the calibration by downloading the chart of a given input range or you can save the calibration table.

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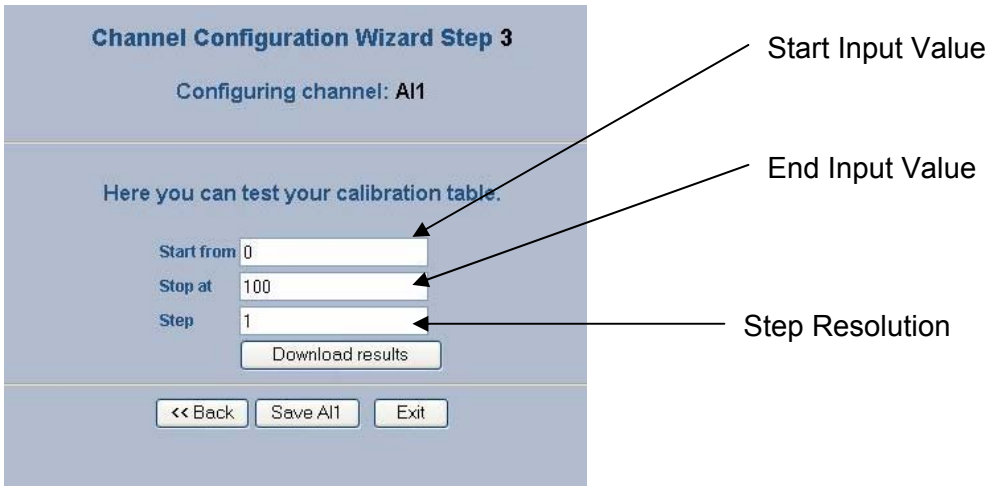

Figure 58 Validating the Calibration Table

Clicking ***Download results*** will export the calculated calibration chart as a .csv type document. After checking the results, select the ***Save*** button to keep the entered calibration table.

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6.1.1.5 Enter Calibration via Formula

Setting up a Formula can be done using the expressions described in the table below. When generating formulas spacing does not matter. Negative numbers are handled as 0-x. The order of operations for the expressions follow standard precedence such as in C Coding.

After entering the formula, select ***Next***, you then have the option of downloading the results and saving the formula.

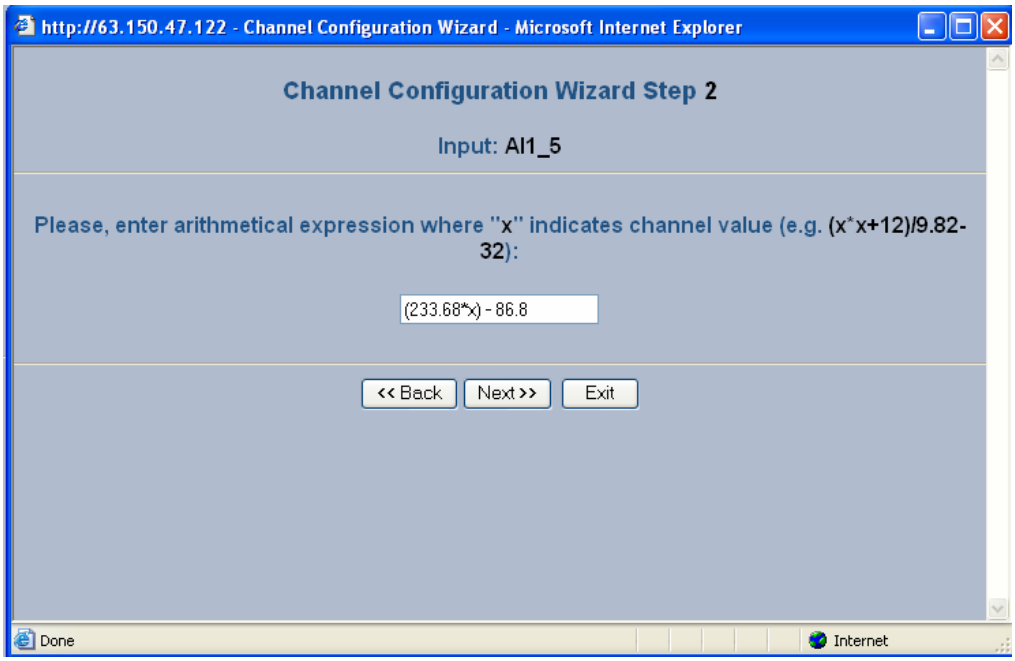

Figure 59 Editing Signal Calibration Formulas

6.1.1.6 Removing the Formula

Removing a formula or calibration table can be done simply by selecting the formula or table under the scaling column, selecting ***Remove***, and clicking ***Next***.

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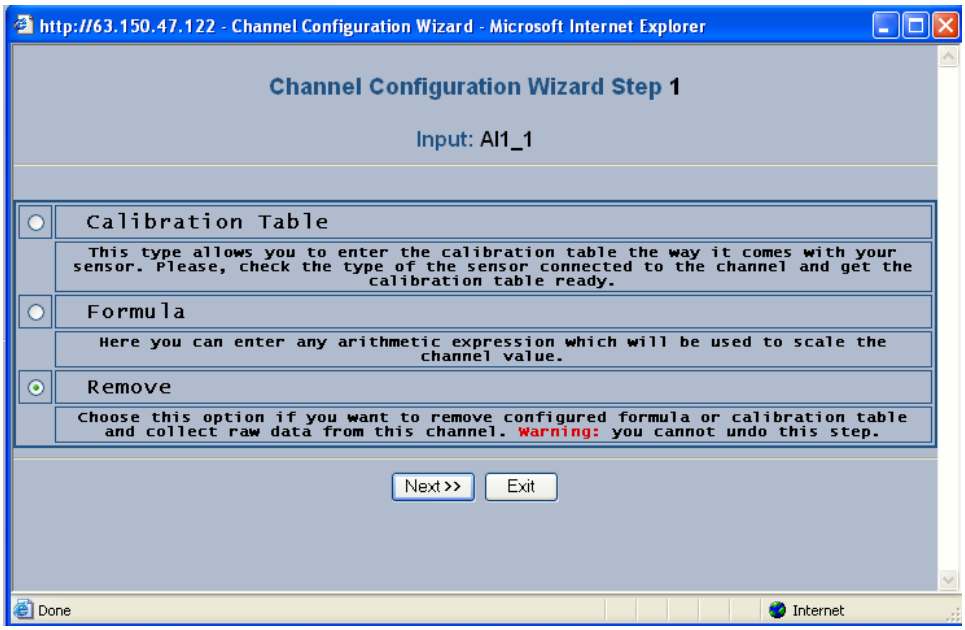
http://63.150.47.122 - Channel Configuration Wizard - Microsoft Internet Explorer
Channel Configuration Wizard Step 1
Input: AI1_1
Calibration Table
This type allows you to enter the calibration table the way it comes with your sensor. Please, check the type of the sensor connected to the channel and get the calibration table ready.
Formula
Here you can enter any arithmetic expression which will be used to scale the channel value.
Remove
Choose this option if you want to remove configured formula or calibration table and collect raw data from this channel. Warning: you cannot undo this step.
Next >>
Exit
Done
Internet

Figure 60 Removing Calibration Formulas/Tables

6.1.1.7 Validating the Signals

Once the signals are named and scaled, select the ***IO Monitor***. This monitoring window can be used to ensure that all of the signals are changing and functioning properly. This window displays the signals with their raw voltage values.

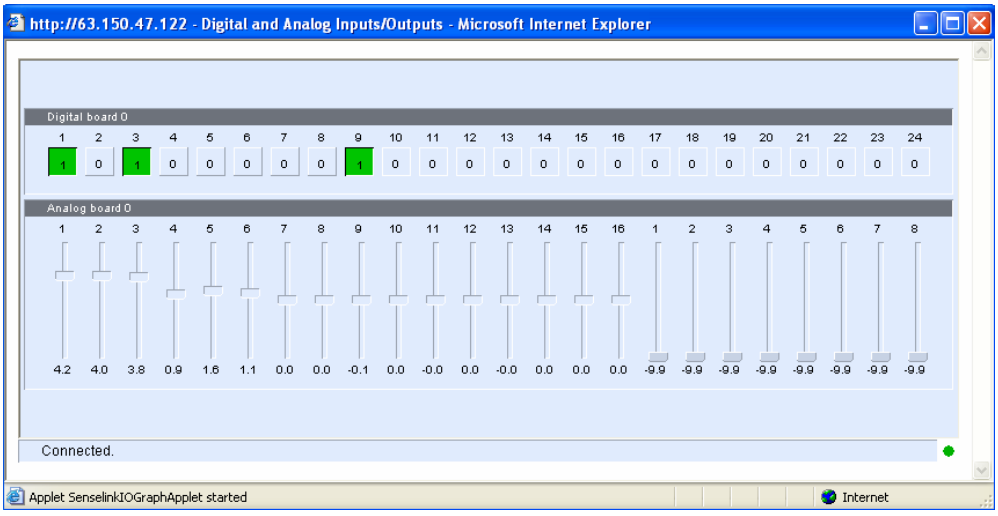

Figure 61 Signals IO Monitor

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6.1.2 Digital Channels

Select the ***Digital*** tab to create or edit digital inputs and label them as outputs or inputs. Select the ***Save*** button when all of the digital signals are entered. Again, the ***IO Monitor*** page can be used to validate the signals.

Figure 62 Editing Digital Signals

6.1.3 Virtual Channels

The Virtuals tab is used to create process data features. A virtual input is used when performing logic and mathematical functions to analog and digital inputs and also events. This allows for complex input functions to be handled in real time by the SenseLink. Each virtual input has a definable description and formula inputs. The ***Edit*** button can be used to modify or delete features.

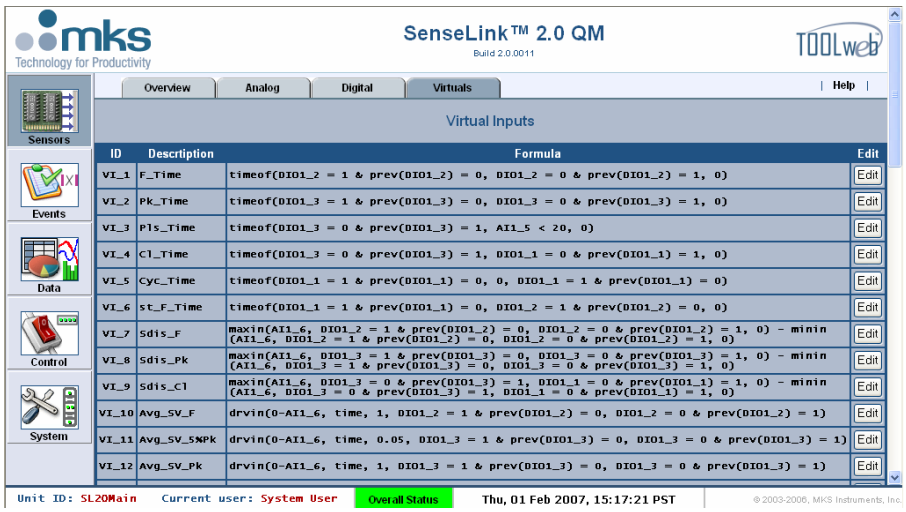
mks
Technology for Productivity
SenseLink™ 2.0 QM
Build 2.0.0011
TOOLweb
Overview
Analog
Digital
Virtuals
Help
Sensors
Events
Data
Control
System
Virtual Inputs
ID Description Formula Edit
VI_1 F_Time timeof(DIO1_2 = 1 & prev(DIO1_2) = 0, DIO1_2 = 0 & prev(DIO1_2) = 1, 0) Edit
VI_2 Pk_Time timeof(DIO1_3 = 1 & prev(DIO1_3) = 0, DIO1_3 = 0 & prev(DIO1_3) = 1, 0) Edit
VI_3 Pls_Time timeof(DIO1_3 = 0 & prev(DIO1_3) = 1, AI1_5 < 20, 0) Edit
VI_4 Cl_Time timeof(DIO1_3 = 0 & prev(DIO1_3) = 1, DIO1_1 = 0 & prev(DIO1_1) = 1, 0) Edit
VI_5 Cyc_Time timeof(DIO1_1 = 1 & prev(DIO1_1) = 0, 0, DIO1_1 = 1 & prev(DIO1_1) = 0) Edit
VI_6 st_F_Time timeof(DIO1_1 = 1 & prev(DIO1_1) = 0, DIO1_2 = 1 & prev(DIO1_2) = 0, 0) Edit
VI_7 Sdis_F maxin(AI1_6, DIO1_2 = 1 & prev(DIO1_2) = 0, DIO1_2 = 0 & prev(DIO1_2) = 1, 0) - minin (AI1_6, DIO1_2 = 1 & prev(DIO1_2) = 0, DIO1_2 = 0 & prev(DIO1_2) = 1, 0) Edit
VI_8 Sdis_Pk maxin(AI1_6, DIO1_3 = 1 & prev(DIO1_3) = 0, DIO1_3 = 0 & prev(DIO1_3) = 1, 0) - minin (AI1_6, DIO1_3 = 1 & prev(DIO1_3) = 0, DIO1_3 = 0 & prev(DIO1_3) = 1, 0) Edit
VI_9 Sdis_Cl maxin(AI1_6, DIO1_3 = 0 & prev(DIO1_3) = 1, DIO1_1 = 0 & prev(DIO1_1) = 1, 0) - minin (AI1_6, DIO1_3 = 0 & prev(DIO1_3) = 1, DIO1_1 = 0 & prev(DIO1_1) = 1, 0) Edit
VI_10 Avg_SV_F drvin(0-AI1_6, time, 1, DIO1_2 = 1 & prev(DIO1_2) = 0, DIO1_2 = 0 & prev(DIO1_2) = 1) Edit
VI_11 Avg_SV_5%Pk drvin(0-AI1_6, time, 0.05, DIO1_3 = 1 & prev(DIO1_3) = 0, DIO1_3 = 0 & prev(DIO1_3) = 1) Edit
VI_12 Avg_SV_Pk drvin(0-AI1_6, time, 1, DIO1_3 = 1 & prev(DIO1_3) = 0, DIO1_3 = 0 & prev(DIO1_3) = 1) Edit
Unit ID: SL20Main
Current user: System User
Overall Status
Thu, 01 Feb 2007, 15:17:21 PST

Figure 63 Creating/Editing Virtuals

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6.2 Events Overview

Selecting the main tab ***Events*** will bring up the following window. On this page, the events, triggers, and status of the events can be modified.

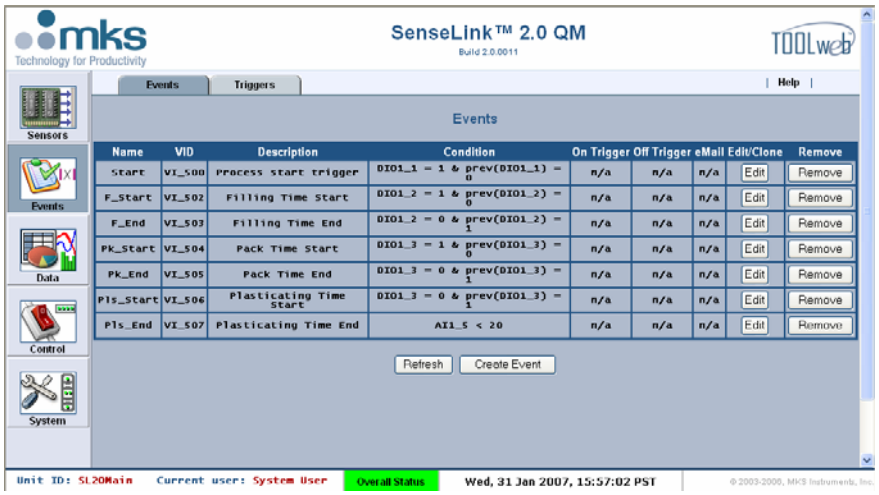
SenseLink™ 2.0 QM
Events
Triggers
Help
Sensors
Events
Data
Control
System
Name VID Description Condition On Trigger Off Trigger eMail Edit/Clone Remove
Start VI_500 Process start trigger DIO1_1 = 1 & prev(DIO1_1) = 0 n/a n/a n/a Edit Remove
F_Start VI_502 Filling Time Start DIO1_2 = 1 & prev(DIO1_2) = 0 n/a n/a n/a Edit Remove
F_End VI_503 Filling Time End DIO1_2 = 0 & prev(DIO1_2) = 1 n/a n/a n/a Edit Remove
Pk_Start VI_504 Pack Time Start DIO1_3 = 1 & prev(DIO1_3) = 0 n/a n/a n/a Edit Remove
Pk_End VI_505 Pack Time End DIO1_3 = 0 & prev(DIO1_3) = 1 n/a n/a n/a Edit Remove
Pls_Start VI_506 Plasticating Time Start DIO1_3 = 0 & prev(DIO1_3) = 1 n/a n/a n/a Edit Remove
Pls_End VI_507 Plasticating Time End AI1_5 < 20 n/a n/a n/a Edit Remove
Refresh
Create Event
Unit ID: SL20Main
Current user: System User
Overall Status
Wed, 31 Jan 2007, 15:57:02 PST

Figure 64 Creating/Editing Process Events

6.2.1 Events

Events are created to separate the different timing stages or events of the injection molding process and simplify the analysis. The typical events that should be created are cycle start and end, filling start and end, packing start and end, and plasticating start and end. These events can then be easily referred to when creating the data features or virtuals. Selecting the ***Create Event*** tab will bring up the following window. Edit the name, description, and condition for the event then select ***Save Event***.

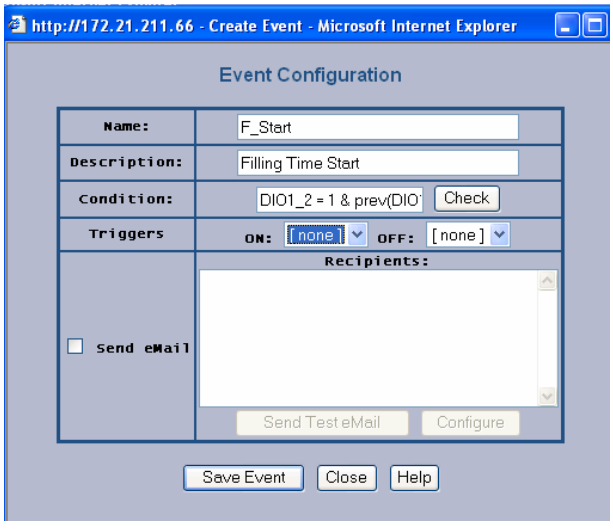

Figure 65 Configuring Events

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6.2.2 Triggers

Triggers are used to create some type of action such as a light or conveyer when a part is accepted or rejected. Setting the conditions for the triggers can be done in the same manner as setting the formulas in the Virtual tab. The condition formulas support the same operators as virtual inputs.

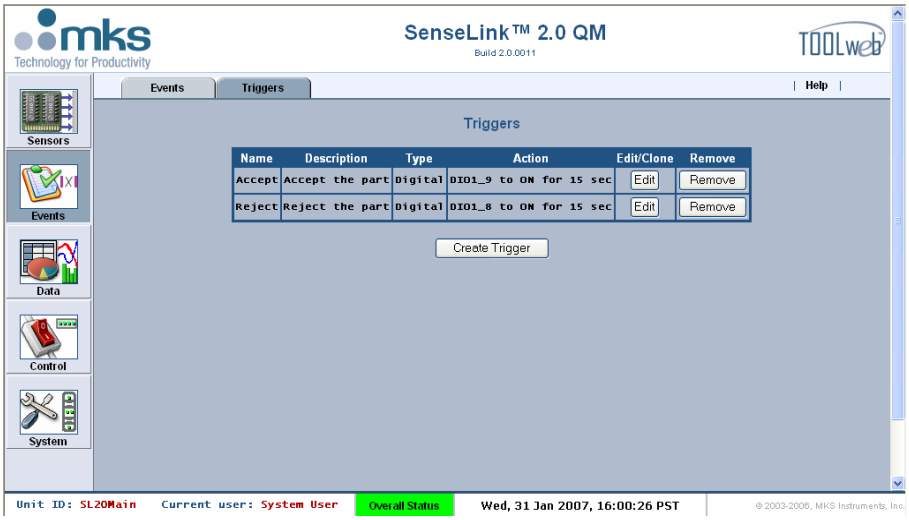

Figure 66 Creating/Editing/Removing Triggers

Select ***Create Trigger*** and the following window displays. Enter the name of the trigger, the description, and type, then select ***Next***. Then configure the trigger with an action and select ***Save*** when complete.

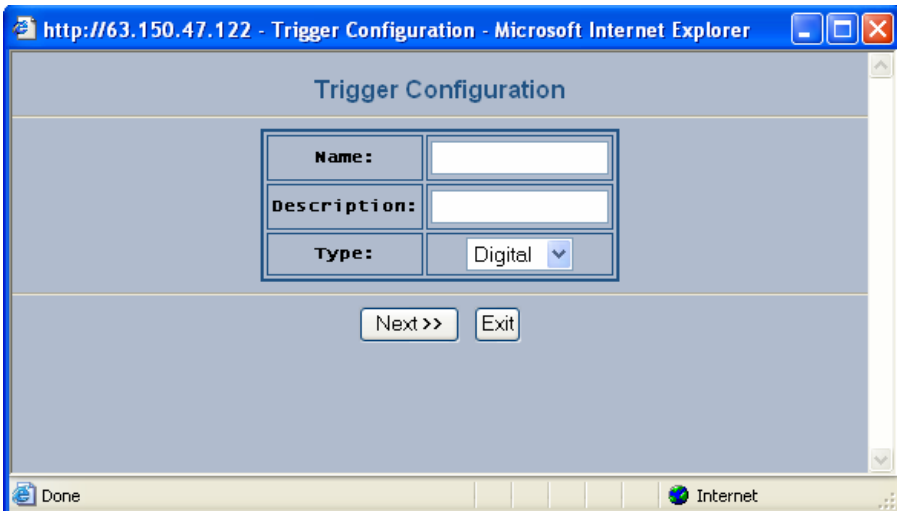

Figure 67 Creating Triggers

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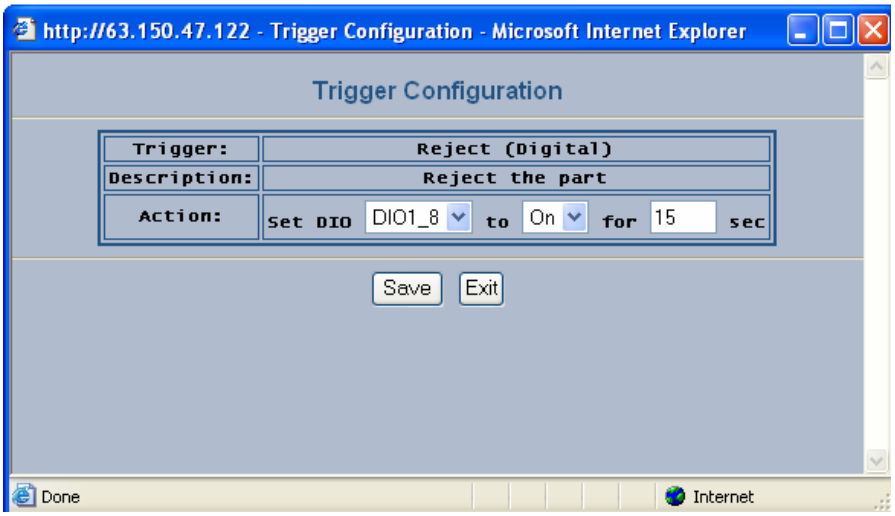

Figure 68 Creating Trigger Names

6.3 Data Overview

The main Data tab displays the Traces, MVA, MVA Report, and Export tabs.

6.3.1 Traces

Traces are collection plans that define how, what, and when data is monitored and stored. By default the DataCP collection plan is setup as the modeling collection plan with only virtuals selected and the Test collection plan is setup for viewing of raw analog and digital signals. Collection plans can be created, edited, charted, and exported for analysis from the Trace Window. Select ***Create*** to enter a new collection plan.

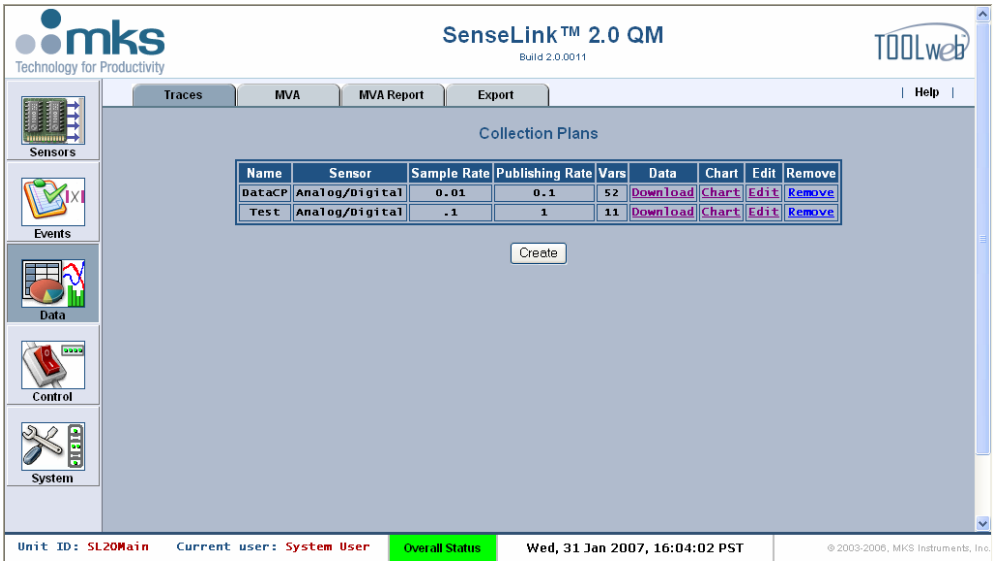

Figure 69 Creating Collection Plans

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Enter the collection plan name, sensor, sampling rate, and publishing rate and select ***Next***.

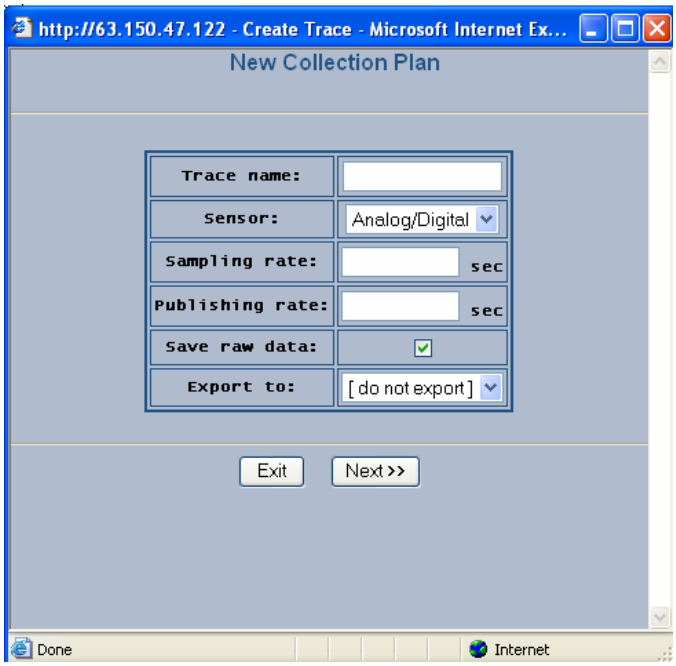

Figure 70 Creating Collection Plans

Select the virtual, analog, and digital signals that need to be monitored during the data collection and modeling and click on the single arrow key, then select ***Save***.

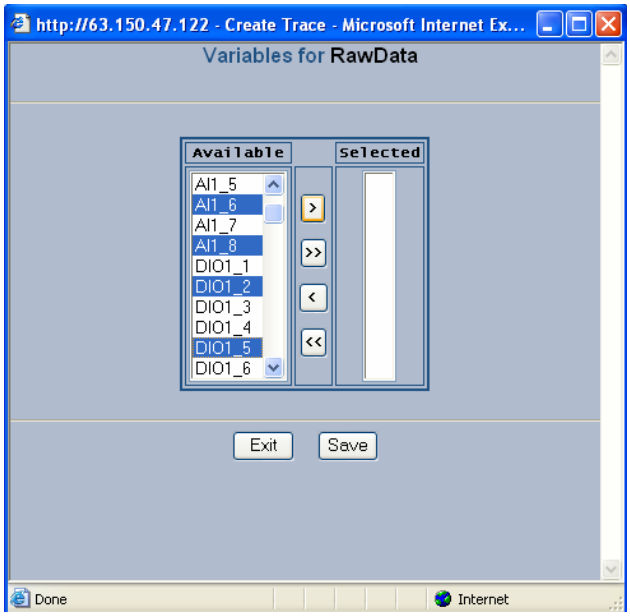

Figure 71 Selecting Variable to Analyze in Collection Plan

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Then select ***Chart*** to graph the data. While the machine is idle, the signals should not be changing and should look like the following the chart. Unselect ***Check All*** to clear the screen then select only the variables that you want to observe.

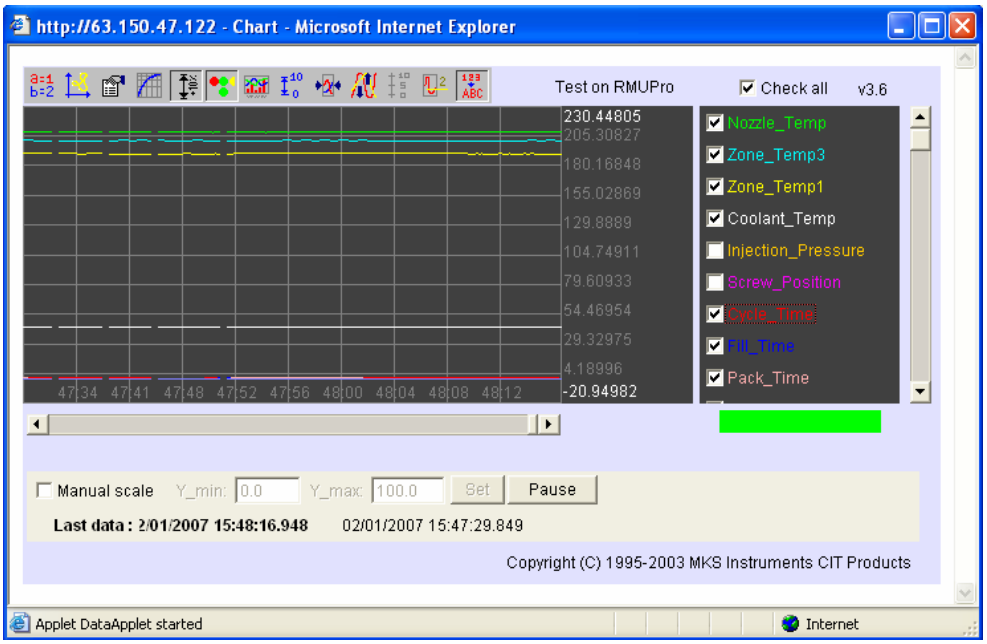

Figure 72 Graphing the Data

Selecting the ***A=1/B=1*** tab in the top left corner will create a chart showing the actual values of the signals and can be seen below.

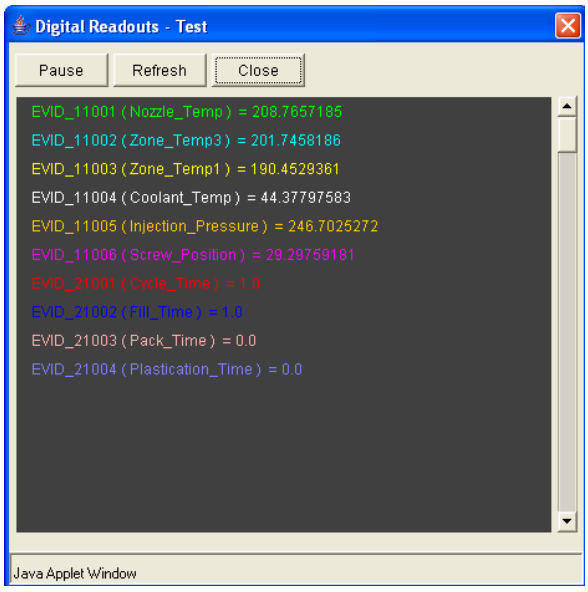
Digital Readouts - Test
Pause
Refresh
Close
EVID_11001 (Nozzle_Temp) = 208.7657185
EVID_11002 (Zone_Temp3) = 201.7458186
EVID_11003 (Zone_Temp1) = 190.4529361
EVID_11004 (Coolant_Temp) = 44.37797583
EVID_11005 (Injection_Pressure) = 246.7025272
EVID_11006 (Screw_Position) = 29.29759181
EVID_21001 (Cycle_Time) = 1.0
EVID_21002 (Fill_Time) = 1.0
EVID_21003 (Pack_Time) = 0.0
EVID_21004 (Plastication_Time) = 0.0
Java Applet Window

Figure 73 Signal Readouts

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6.3.1.1 Creating and Editing Traces

Creating or editing a trace allows new or existing collection plans to be defined. In the ***Edit*** or ***Create*** window collection plans are defined and parameters are selected.

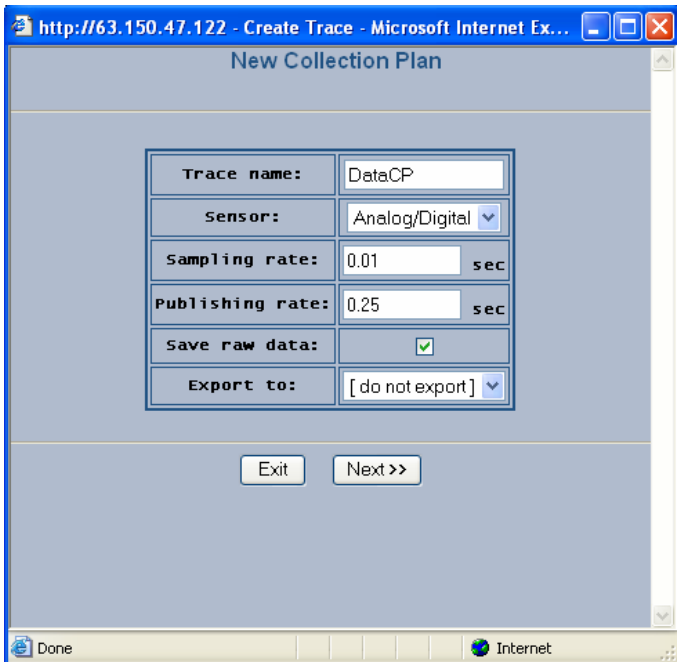

Figure 74 Creating Collection Plans

When creating a trace the collection plan is named, and a publishing and a sample rate are defined. The publishing rate is how many samples per second are saved. The value that is stored is the last sample that was read per second. The sampling rate is the number of data readings taken per second. The reason for having a separate publishing and sample rate is to allow more sampling to reduce the likelihood of missing an event and to save storage space for long term data collection. By default the sampling rate is set to 10 ms and the publishing rate to 100 ms.

CAUTION

Removing a trace will impact the data collection done by a TOOLweb tool side client.

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6.3.1.2 Charting Trace Data

Charting data allows the user to see plots of the values for analog, digital, and virtual inputs.

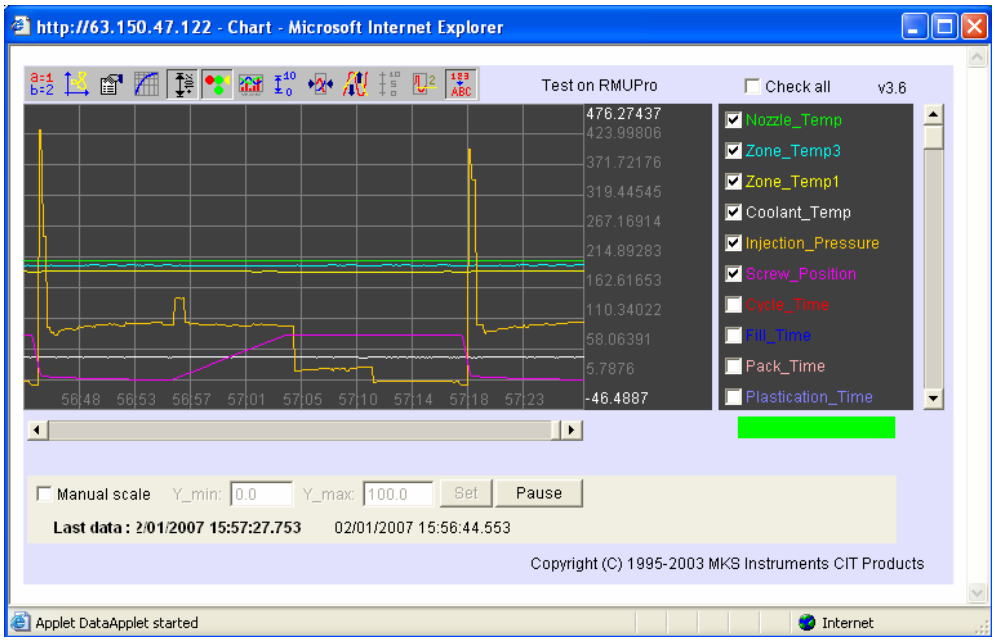

Figure 75 Charting Collection Plan Data

The chart applet has a tool bar to provide customization and aid in the analysis of the inputs.

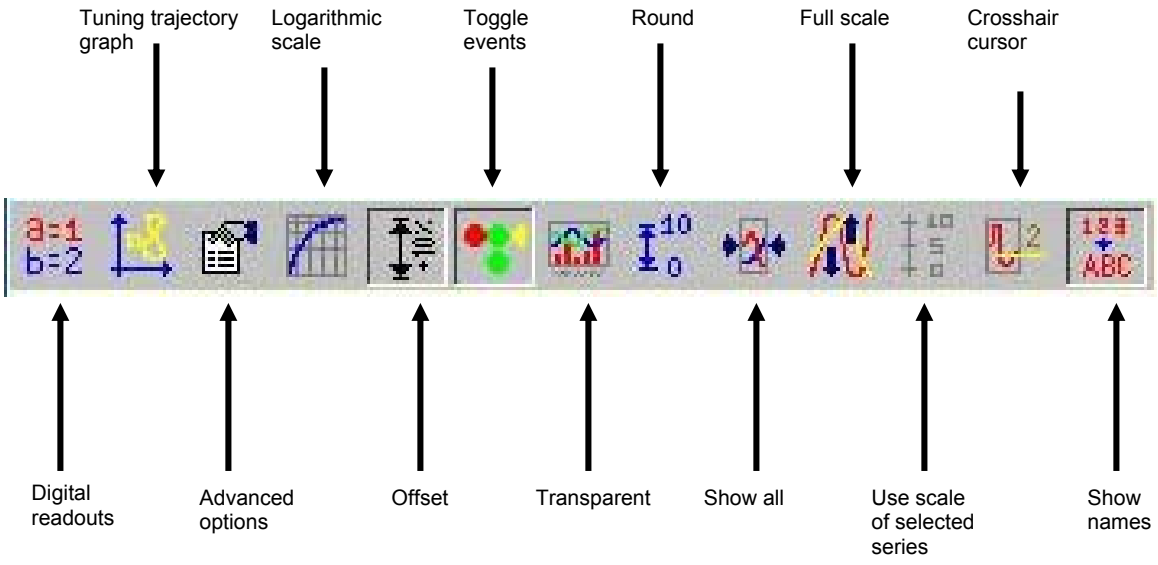

Figure 76 Creating Collection Plans

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Zoom	The charting provides one level zoom functionality. To move in, move your mouse in a rectangular mode over the chart. If you select manual mode, and define the Y range, you can only scale X by zooming in. To zoom out, click on the chart.
Manual Scale	Check manual scale to define the minimum and maximum of the Y-axis. The entry will be valid for all scale units.
Pause	Check pause to stop the chart from moving.
Digital Readouts	Here the collected inputs are listed in realtime, which means that the values are changing according to the sample interval. Press the pause button if you want to stop the values from changing.
Logarithmic Scale	Check logarithmic scale to recalculate the graph. The lowest values will be scaled the largest.
Offset	Check use offset to have a free space of 10% below and above the graph. If you uncheck use offset, data points will be displayed directly on the x- axis
Invert Background	Check invert background if you want to change the background color from black (default) to gray.
Round	Check *round* to round the scaling
Advanced Options	Press *advanced* to customize the graph, select a parameter from the drop down menu and adjust as you like
Show All	Check *show all data series on one screen* to all buffered data on one screen.
Transparent	Lines will be displayed transparent.
Full scale display	Full scale means that all series are scaled to fit the screen vertically
Show Names	Show series names instead of numbers
Crosshair	Shows the crosshair cursor, displaying X-Axes and Y-axes values
Trajectory Chart	Opens a new window for the tuning trajectory chart.

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6.3.1.3 Downloading Trace Data

Exporting trace data provides flexibility for data extraction from the SenseLink™. The data is stored in a circular buffer always keeping current data. Once the buffer is full the oldest data is discarded. When exporting data, the time window and format of the data is selectable.

The default time window displays for the entire content of the buffer. The start and stop time can be modified if specific data is required. The Export Window allows the format for charting applet, CSV (Excel\spreadsheet format), and plain comma delimited text, and will store up to 40 MB of data.

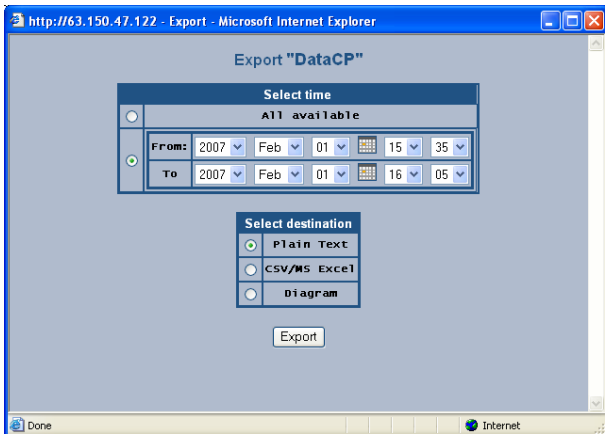

Figure 77 Exporting Data

6.3.2 MVA

Selecting the ***MVA*** tab will bring up the main SenseLink page. From this page, any previous data can be downloaded and displayed on the MVA target, displaying what parts are in and out of spec based on the current running model.

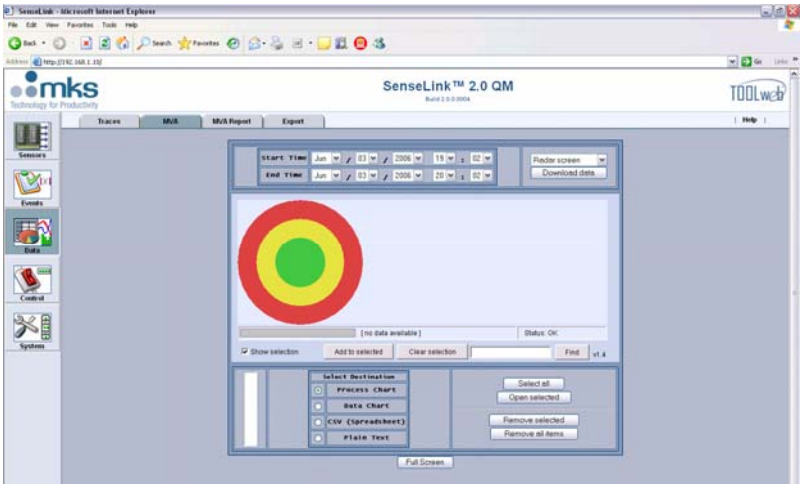

Figure 78 SenseLink MVA Main Page

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Once a processing time frame is chosen and the data is downloaded, the data appears on the target where each dot represents one molded part. Any parts that show up in the red area are outside of the set MVA limits and will be automatically rejected. The plot next to the target represents a contribution plot which calculates the MVA summary statistics for each variable and determines the data feature or features responsible for the process variation.

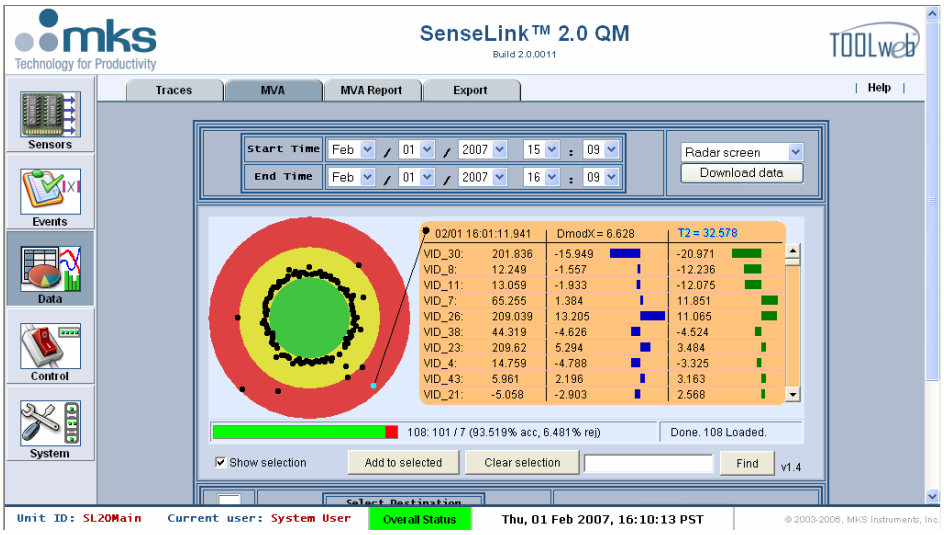

Figure 79 Real-Time Part Evaluation

6.3.2.1 Downloading Summary Data

Under the MVA tab, cycle summary data can be downloaded onto the radar screen, onto a data chart, into a .csv file, or into a text file. This can all be done be done by selecting the drop down arrow above the Download Data button shown below. The data downloaded here will display both the values of each of the selected inputs along with all of the MVA statistics, as opposed to downloading data from the Traces tab which only displays the input values.

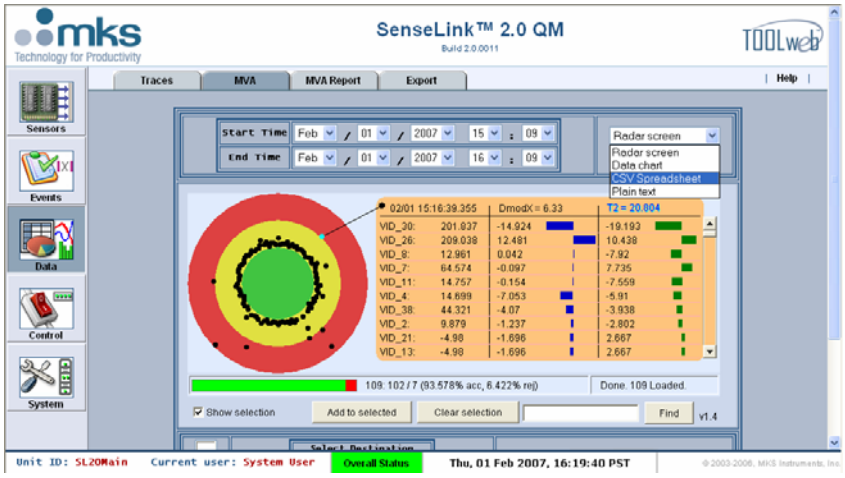

Figure 80 Downloading Summary Data

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6.3.2.2 Downloading Raw Data

Under the same MVA tab, raw data can also be downloaded. Select specific points or parts of interest and select the ***Add to Selected*** button. The parts are then displayed in a table in the bottom left. You must then select the ***Select All*** button to highlight the parts. The user then has the option to examine the data in a Process Chart, Data Chart, CSV Spreadsheet, or Plain Text by selecting the data method and selecting ***Open Selected***.

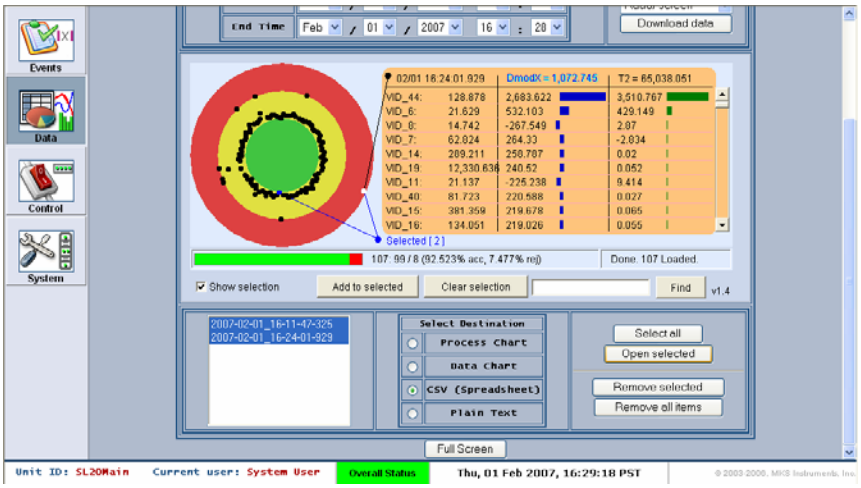

Figure 81 - Downloading Raw Data

Selecting Process Chart will allow the user to examine multiple parts and view the individual traces of each cycle. This option also gives the user the ability to overlay traces from a specific cycle over other cycles. The following figure is displaying the injection pressure of the two parts shown above. As can be seen from the chart, the two pressure traces exhibit significant differences in hold time.

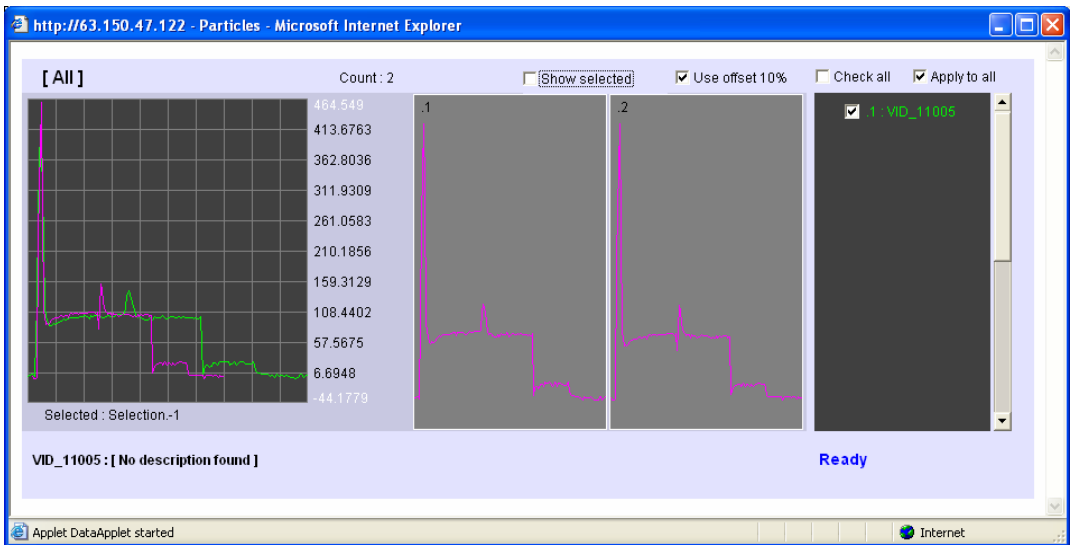

Figure 82 Overlaying Pressure Traces of Multiple Cycles

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6.3.3 MVA Report

MVA reports can then be created which give a summary of the total parts being accepted and rejected. This can be done by selecting the time frame of data needed, and either selecting ***Open Report***, Figure 81, or selecting the total efficiency or raw data export along with preferred data file.

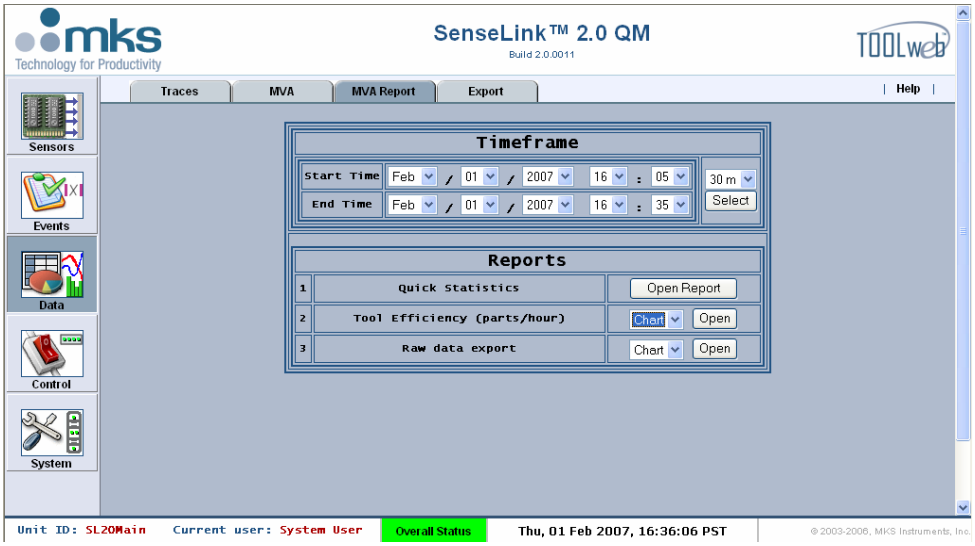

Figure 83 Creating MVA Reports

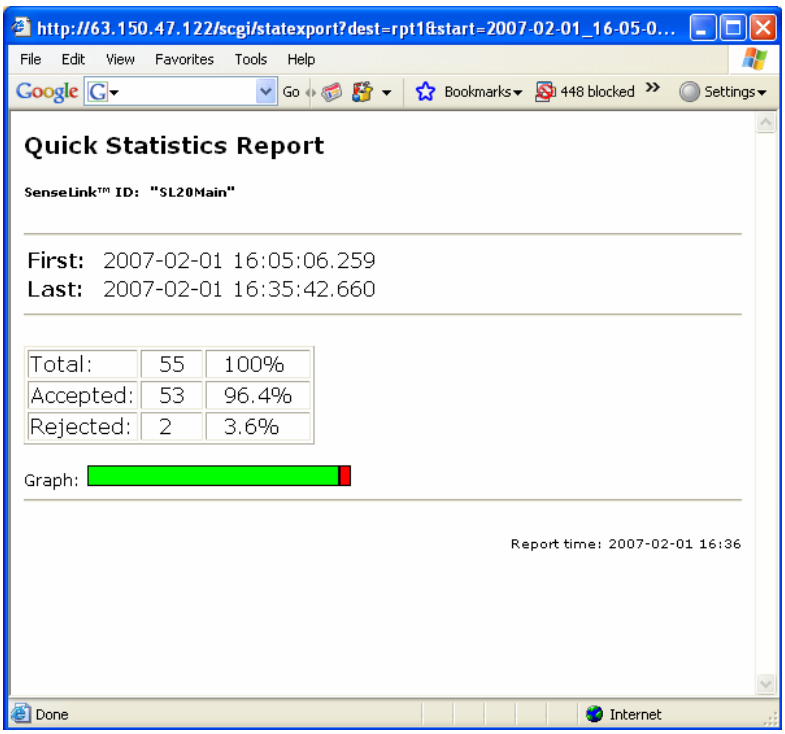

Figure 84 Quick Statistics Report

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6.3.4 Export Data

Selecting the ***Export*** tab gives the user the ability to move the data from the SenseLink to another location such as a server for future analyzing.

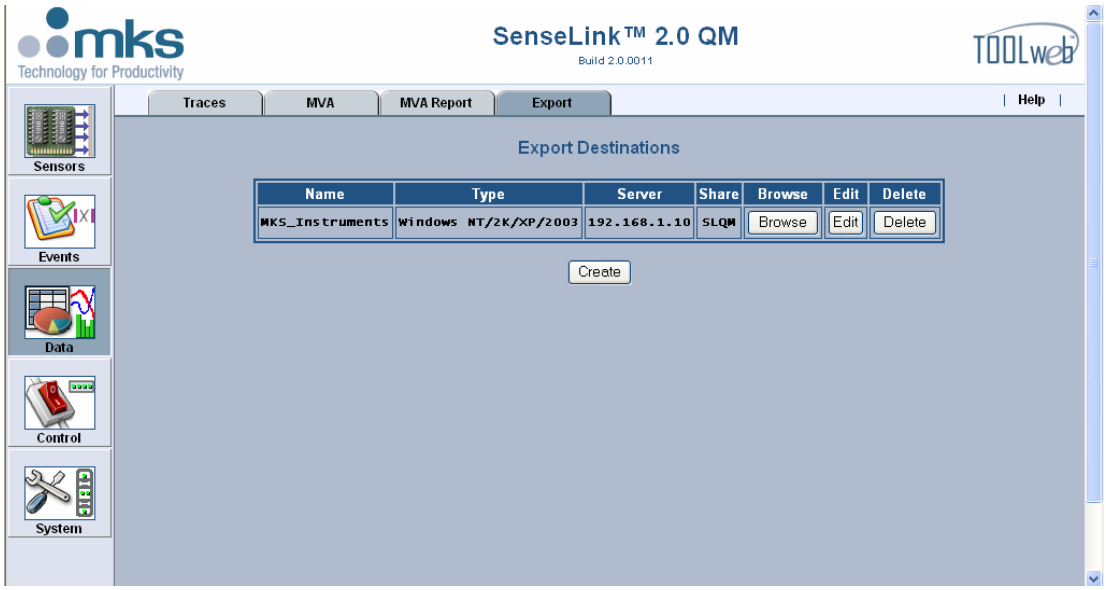

Figure 85 Exporting Process Data

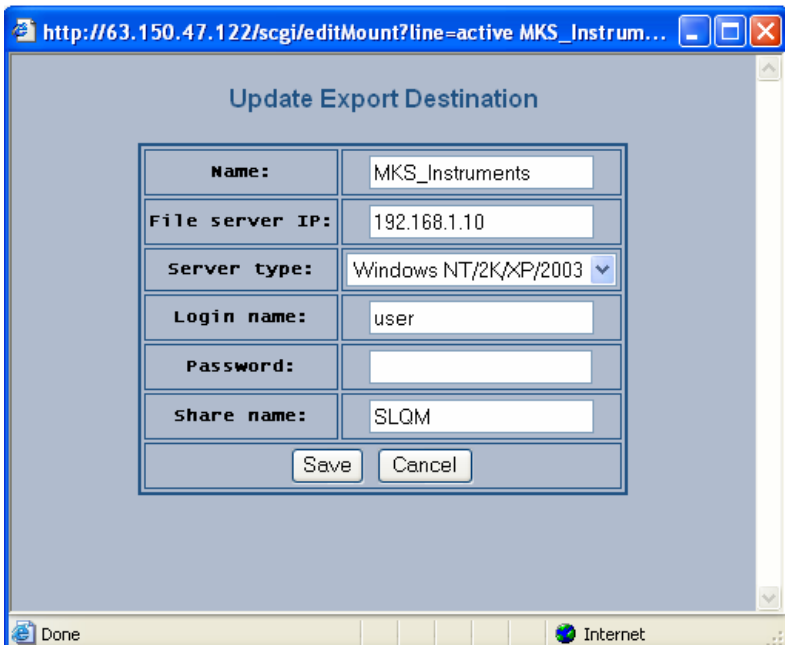

Figure 86 Data Exporting Location

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6.4 Control Overview

Selecting the Controls main tab gives the user the ability to create a model under the ***MVA Config*** tab and to run a DOE and collect data under the ***MVA DoE*** tab.

When running a DOE, name the DOE and define a time period when data is going to be collected. Then click ***Start***. The box in the right corner will no longer say idle and it should turn green, now it is collecting data.

After the DOE has been run, the data will be saved under the Data section shown below. The data can then be downloaded offline to SIMCA P+ for analysis or a model can be created online.

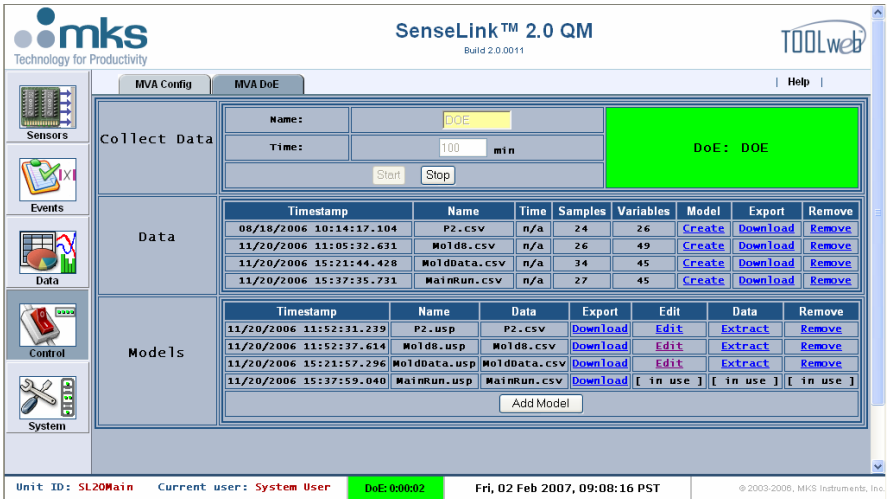

Figure 87 Running DOE

To create a model online, select the ***Create*** button where the data is displayed. A model is then created based on the DOE and displays under the Models section.

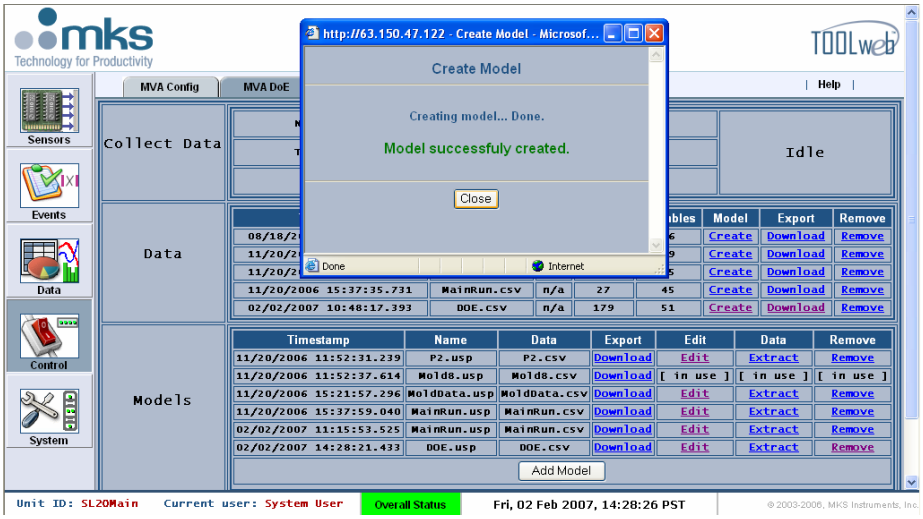

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Figure 88 Creating a Model

Viewing or rebuilding the model can then be done by selecting ***Edit*** model. Points can be selected or removed and the model can be rebuilt. The model is displayed as a first and second component scatter plot.

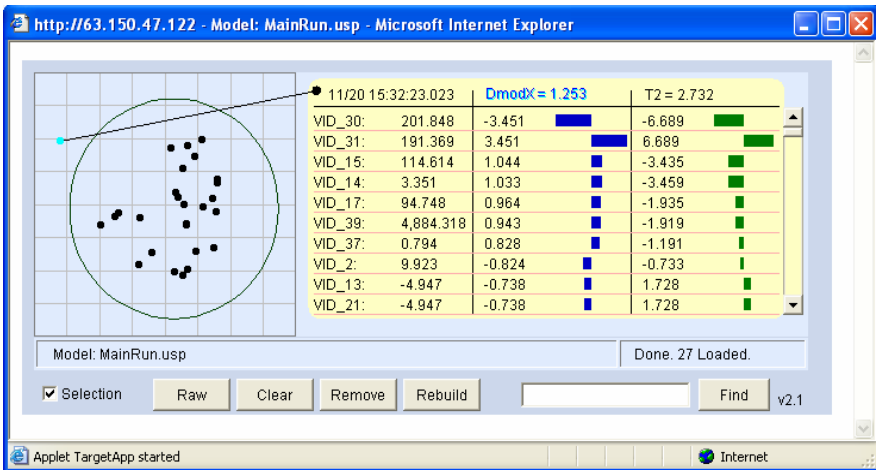

Figure 89 Viewing/Rebuilding Model

Once the model is created, selecting the ***MVA Config*** tab gives the user the ability to activate that model and set the control limits. The first step, before activating the model, is to ensure that the DataCP collection plan is selected. The DataCP should have been selected prior to running the DOE as it consists of all of the virtual or data feature inputs which the model is created from. Also be sure to select the event "Start", as it is setup as mold open (cycle start and cycle end), for both Process Start and Process Stop. Select the triggers for Accept and Reject and also for Health DIO select the System OK digital output which by default is DIO1_10. Then select ***Activate*** to submit the changes. To activate the new model, select the model from the drop down box shown below.

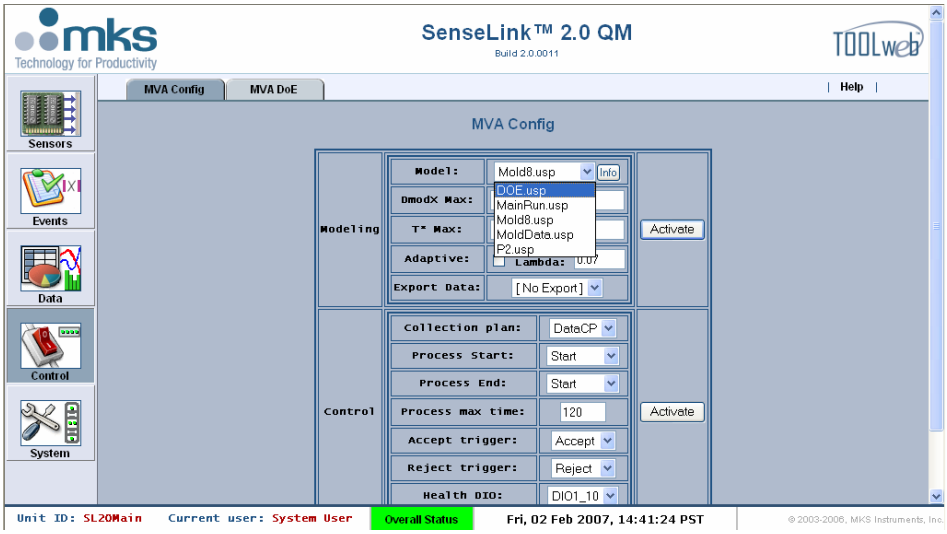

Figure 90 Selecting New Model

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Then select ***Info***, which displays the statistics and suggested control limits for the model. Selecting ***Copy Limits*** will then put the suggested limits in place for the model. A validation trial is then typically done to refine the model limits if necessary. Then select ***Activate***. The new model is now comparing any new molded part data to the model. The first two to three shots following the activation of a new model will always result in rejected parts. The results of the new model can then be observed under the Data MVA tab.

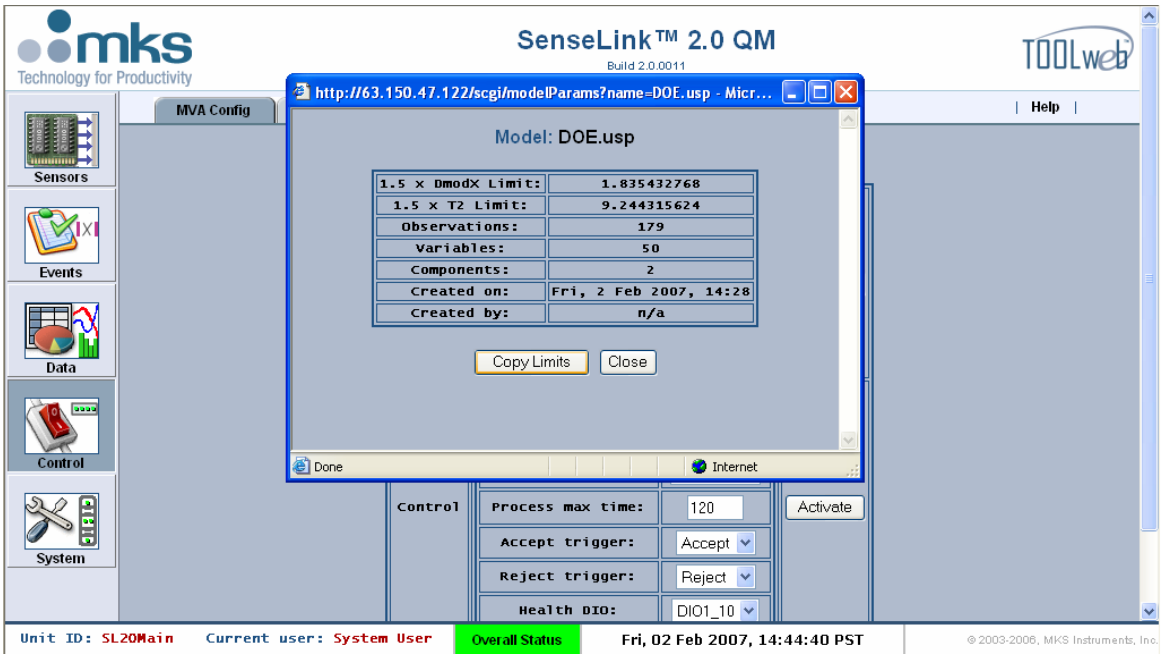

Figure 91 Copying Model Limits

6.5 System Overview

The system tab allows you to do the following:

- Monitor alarms
- Adjust network settings
- Modify date and time settings
- Add/Edit users and profile information
- Perform basic diagnostics
- Update/Export the SenseLink™ software and view the update history

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6.5.1 Alarms

Alarms are displayed to represent the system health of the SenseLink, and can be found in the Alarms tab.

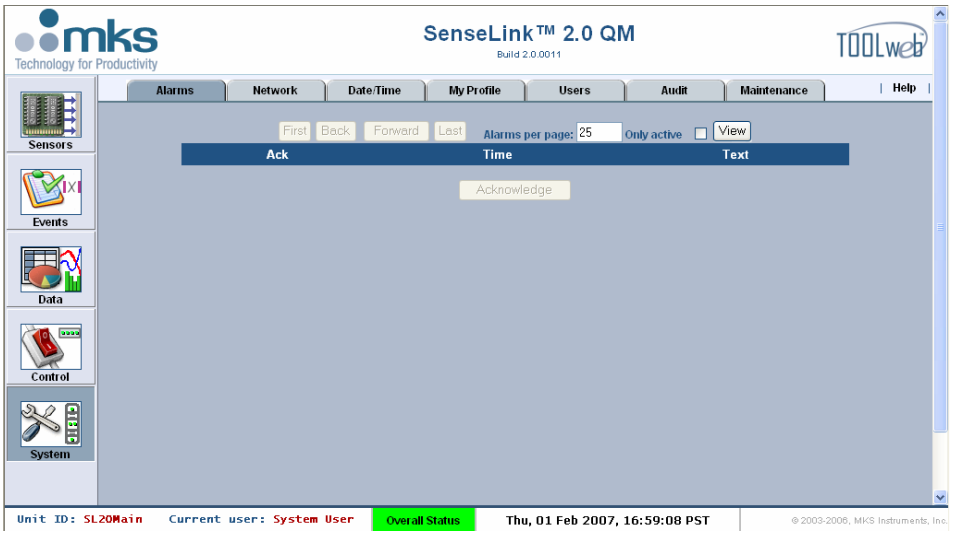

Figure 92 System Main Tab/Alarms Tab

6.5.2 Network

You can change the IP-Address, Subnet mask and Default Gateway via the user interface. Changes to the setup will become active after a reboot of the SenseLink™ or after you tested the new settings successfully and confirmed the changes.

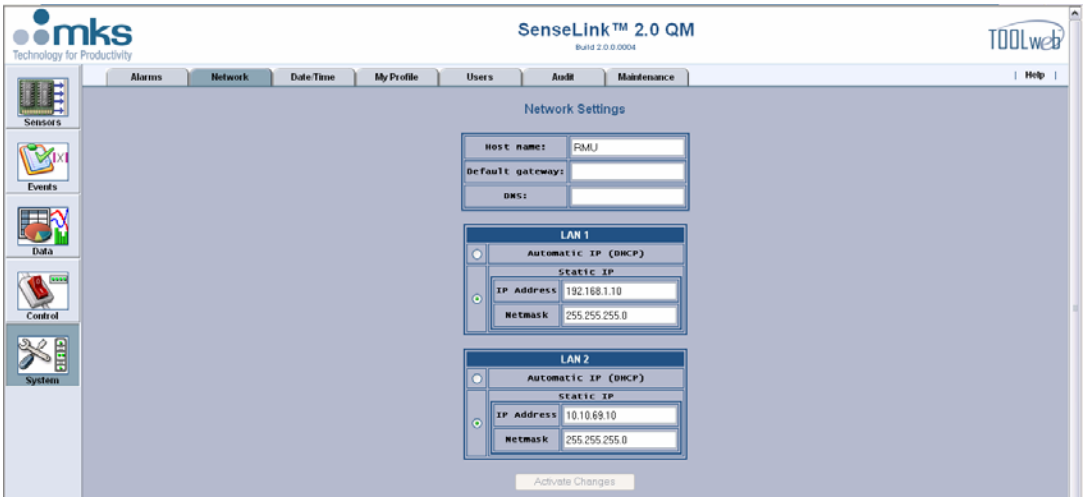

Figure 93 Network Tab

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6.5.3 Date/Time

The date/time tab allows users to set the time zone and the time of the system. Select ***Activate Changes*** when the time is entered.

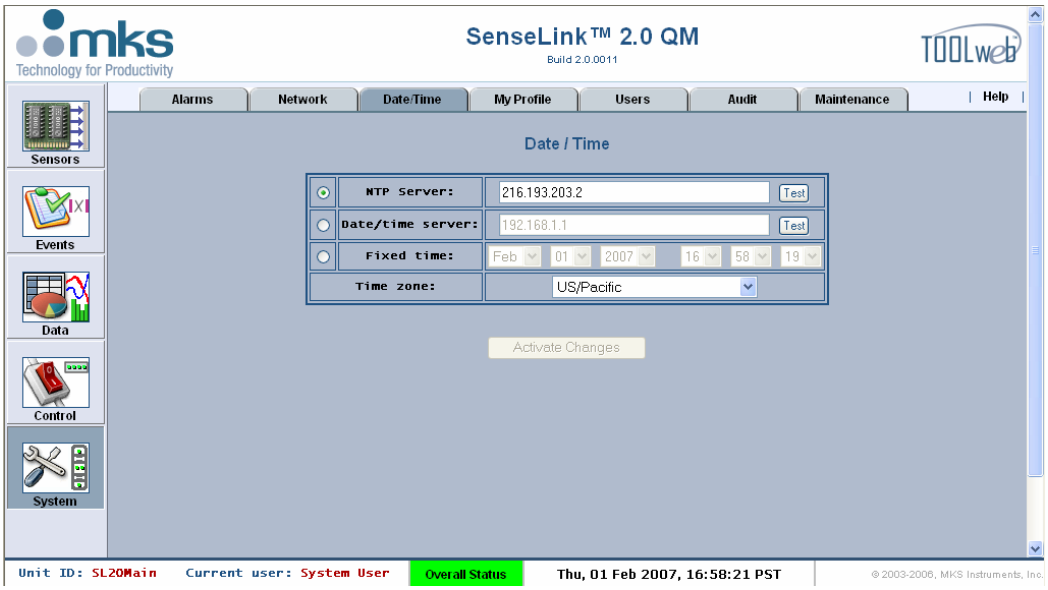

Figure 94 Data Time Tab

6.5.4 My Profile

To change a user's password select the ***My Profile*** tab and enter in the old password along with the new one entered twice. Also the homepage of the SenseLink, when that user logs in, can be changed here. Select the drop down arrow and select any of the pages to be the home page.

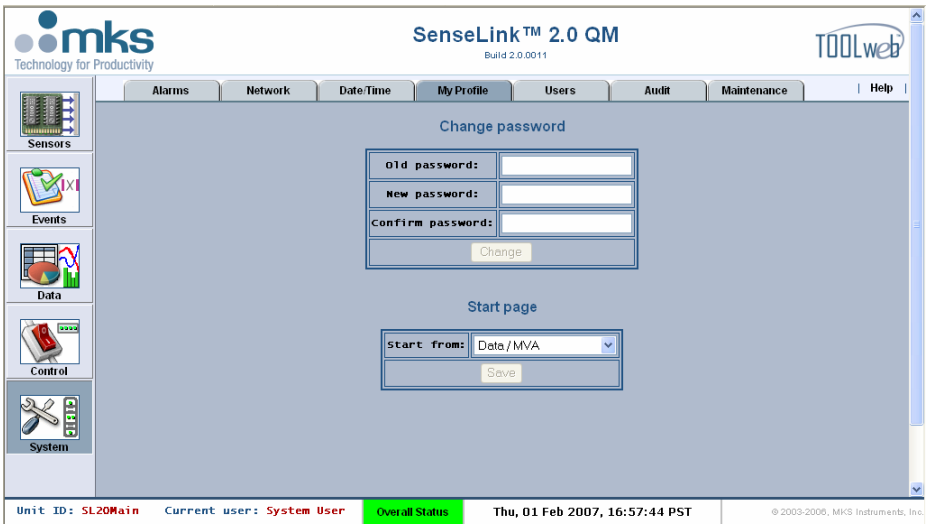

Figure 95 Editing SenseLink Password and Profile

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6.5.5 Users

Selecting the ***Users*** tab will allow the administrator to add users to the system and to edit the access rights of the user. Select ***Edit*** under Access rights and allow full access, read-only, or no access to each of the users.

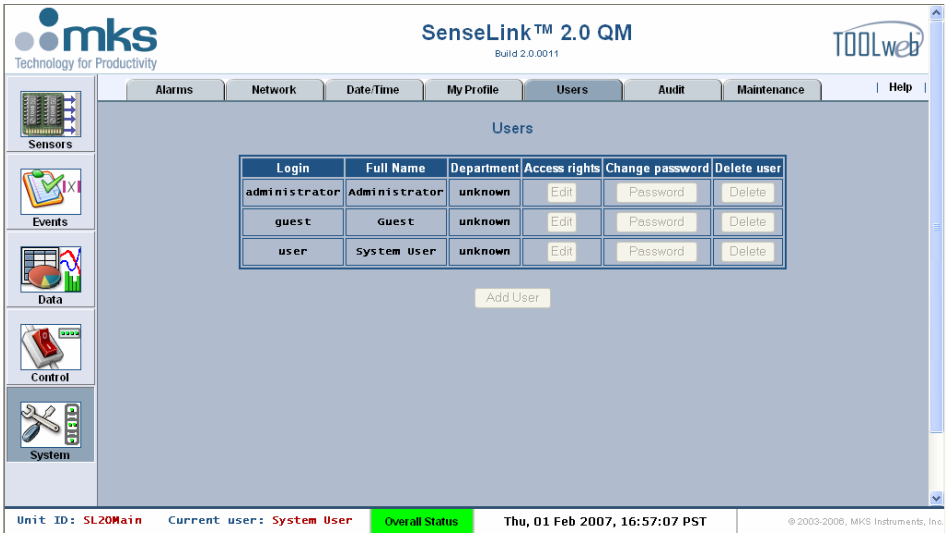

Figure 96 Editing Users of the SenseLink

6.5.6 Audit

The Audit tab allows users to see all of the changes that have been made in the SenseLink and who has made them. Changing the number of Records per page will allow the user to view past changes.

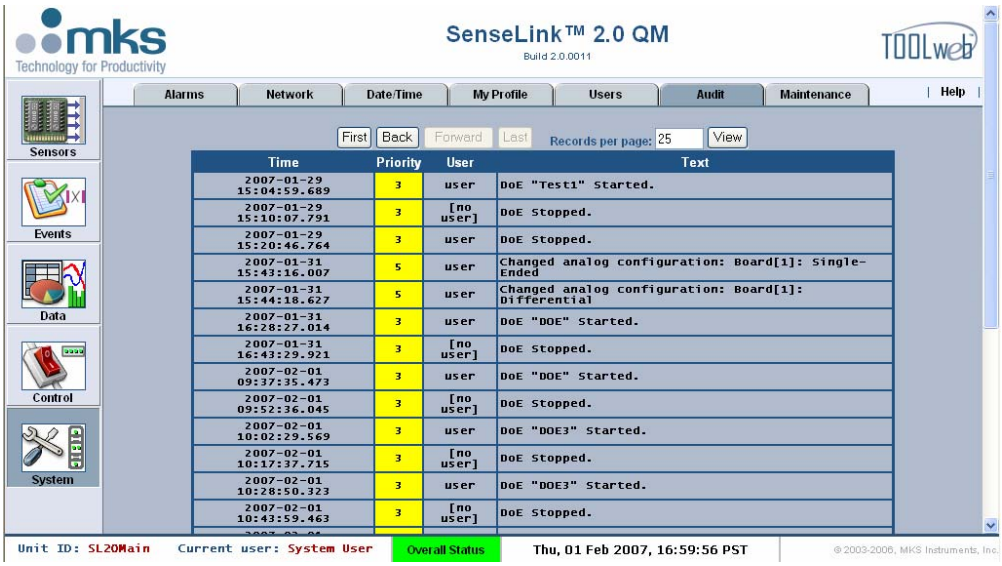

Figure 97 Audit Tab

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6.5.7 Maintenance

The Maintenance tab gives users the ability to perform diagnostics, to export the unit's configuration, to view any other SenseLinks on the network, to edit the emailing of the system, and to update the systems software.

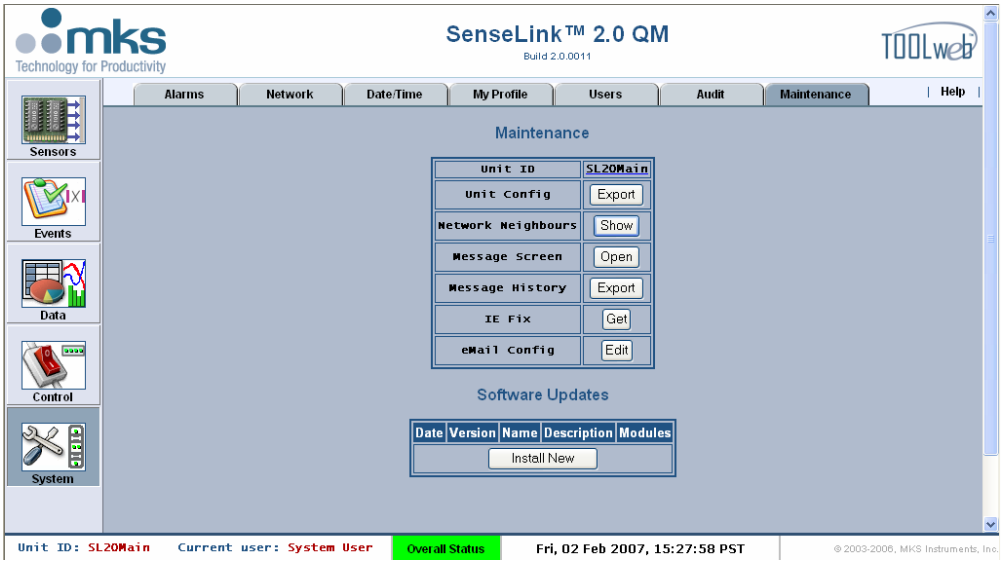

Figure 98 Maintenance Tab

You can perform basic diagnostics by selecting ***Open*** for the Message Screen, displaying debug messages from the web server and analog/digital driver. The SenseLink™ QM does not support local storage of diagnostic log files.

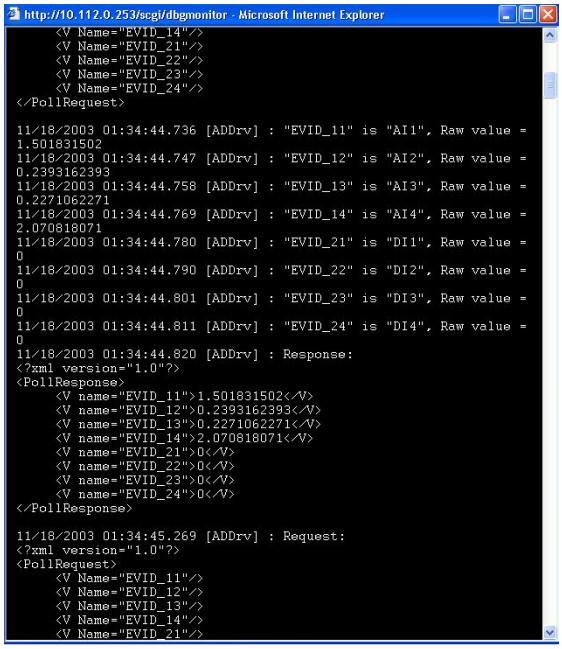

Figure 99 Diagnostic Monitor

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The following steps are required to update the SenseLink™ QM software:

- Click on ***Install New*** in the SenseLink™ System/Maintenance Menu at the bottom of the page.
- A new window will pop up. Click ***Next***.
- ***Browse*** for the update package and click ***Next***.

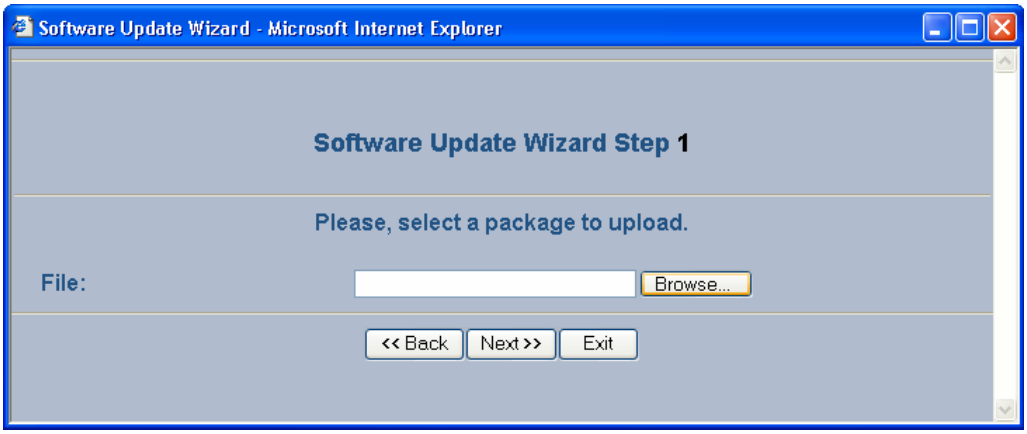

Figure 100 Updating Software

- The SenseLink™ will upload the package and start the installation once you select ***Install*** on the screen below.
- The system will reboot and the changes will take place.

Figure 101 Installing a Packaged Configuration File

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7 Data Features (Virtuals)

Data features are calculated, from the raw data, to more efficiently describe the injection molding process and to provide valuable process outputs to the user. A specific set of data features will initially be created in the SenseLink based on the available process signals. The data features that are used were chosen because they are directly related to the process signals being monitored and they have been proven to be indicative of part quality and material behavior. Any further data features can easily be added by the user.

Some examples of data features and how they are calculated can be seen below (The event name is used in these equations, but the event number is currently used in the calculations):

Description=F_Time
Expression=timeof(F_Start, F_End, 0)

F_Time represents the fill time, and the time is calculated from the moment the filling digital signal turns on to when it turns off. The zero at the end of the formula tells the SenseLink to keep this value to the end of the cycle and to reset it when the next filling digital signal turns on during the next shot.

Description=Cyc_Time
Expression=timeof(Cyc_Start, 0, Cyc_End)

Cyc_Time represents the cycle time, and the zero in the middle of the formula tells SenseLink to reset the value to zero at cycle end which is actually the beginning of the next cycle.

Description=Sdis_F
Expression=maxin(AI1_6, F_Start, F_End, 0) – minin(AI1_2, F_Start, F_End, 0)

Sdis_F represents the screw displacement during the filling stage. This is calculated by taking the maximum of the screw position (AI1_6) from fill start to fill end minus the minimum of the screw position from fill start and fill end; the value is then reset when the digital filling signal turns on again.

Description=Int_InjP_F
Expression=integral(AI1_5, time, F_Start, F_End, 0)

Int_InjP_F represents the integral of the injection pressure during the filling stage. This is calculated by taking the area under the curve or the integral of the injection pressure (AI1_5) with respect to time from fill start to end.

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The table below lists the supported operators.

Table 23 Supported Operators

Expression	Description
+	Indicates addition operation
-	Indicates subtraction operation
/	Division operator
*	Multiply operator
Avgof(Ch. Name, from, to)	Average operator
Drvin(Ch. Name, w/respect to Ch. Name, percent of stage, from, to)	Derivative operator
=	Equality operator
!=	Inverse equality operator
>	Logical compare Greater than
>=	Logical compare Greater than or Equal to
<	Logical compare Less than
<=	Logical compare Greater than
()	Parenthesis for defining or modifying order of operation
&	Logical And
!	Logical Not
^	Order of magnitude
Or	Logical Or
Xor	Logical exclusive Or
Minin(Ch. Name, from, to)	Min input value *Cannot be reset without control function
Maxin(Ch. Name, from, to)	Max input value *Cannot be reset without control function
Timeof(Ch. Name, from, to)	Timeof input value *Cannot be reset without control function
Integral(Ch. Name, w/respect to Ch. Name, from, to)	Integral Operator

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A list of the default data features created from the standard signals is shown below.

Table 24 Standard Data Feature List

SenseLink QM Default Data Features		
Num	**Symbol**	**Description**
1	F_Time	Time of mold filling phase
2	Pk_Time	Time of mold packing phase
3	Pls_Time	Time of screw recovery
4	Cl_Time	Time of mold cooling
5	Cyc_Time	Time of process cycle – mold open to mold open
6	Sdis_F	Screw displacement during filling stage
7	Sdis_Pk	Screw displacement during packing stage
8	Sdis_Pls	Screw displacement during plastication stage
9	Avg_SV_F	Average screw velocity during filling stage
10	Avg_SV_5%Pk	Average screw velocity at VP transfer
11	Avg_SV_Pk	Average screw velocity during packing stage
12	Avg_SV_Pls	Average screw velocity during screw recovery
13	Max_InjP_F	Maximum injection pressure during filling stage
14	Avg_InjP_F	Average injection pressure during filling stage
15	Avg_InjP_Pk	Average injection pressure during packing stage
16	Avg_InjP_Pls	Average injection pressure during screw recovery
17	Inj_E	Total injection energy measured during the filling and packing stages
18	Pls_E	Total plastication energy measured during the plasticating stage
19	Melt_Visc1	Measure of average viscosity of material during filling
20	Melt_Visc2	Measure of average viscosity of material during plastication
21	Max_NzT	Maximum nozzle temp
22	Min_NzT	Minimum nozzle temp
23	Avg_NzT	Average nozzle temp
24	Max_ZoneT1	Maximum zone temp 1
25	Min_ ZoneT1	Minimum zone temp 1
26	Avg_ ZoneT1	Average zone temp 1
27	Max_ZoneT2	Maximum zone temp 2
28	Min_ZoneT2	Minimum zone temp 2
29	Avg_ZoneT2	Average zone temp 2
30	Max_ ZoneT3	Maximum zone temp 3
31	Min_ ZoneT3	Minimum zone temp 3
32	Avg_ ZoneT3	Average zone temp 3
33	Int_InjP_F	Integral of injection pressure during filling stage
34	Int_IntP_Pk	Integral of injection pressure during packing stage
35	Int_IntP_Pls	Integral of injection pressure during plastication
36	Cushion	Minimum screw position at end of packing stage
37	Shot_Size	Maximum screw position at start of filling stage

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8 Appendix

A typical first installation may consist of the following major elements to ease installation:

Table 25 Example SenseLink Hardware Installation

Item	Description	MFG P/N	MKS P/N		Manufacturer	Qty
1	Power supply	8708660000	PS10004	Power supply, 100-240VAC to 24VDC (3A)	Weidmuller	1
2	SenseLink QM	AS00922-02	AS00922-02	RMU2-D-DIDO-AIAO	MKS	1
3	CompactFlash	SDCFH-1024-388	AR00071	CompactFlash, 1G	Sandisk	1
4	Thermocouple Input module	8560720000	SW10009	Type J, K, T, E, N, R, S, B configurable	Weidmuller	4
5	Terminal block	AR10157	AR10157	Terminal block, 37Dsub Female	Weidmuller	2
6	I/O cable	WA10023	WA10023	Cable, Dsub37MF, 2.5ft	L-com	2
7	DIN Rail	BAA1000-x		DIN rail, x " length (30”)	Idec	1

Physical dimensions are 30” long x 5” high x 5” deep.

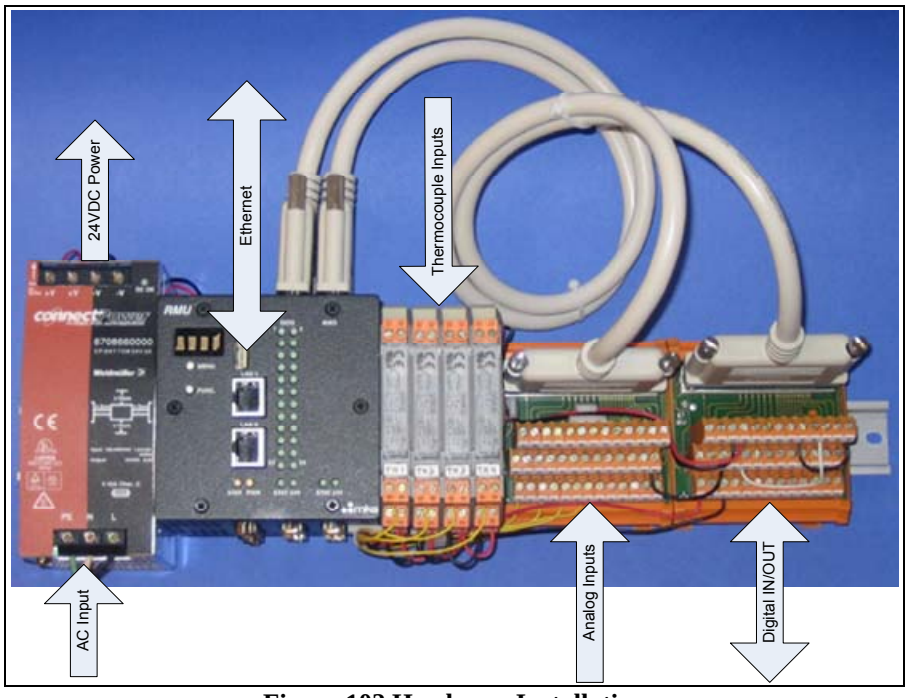

Figure 102 Hardware Installation

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9 Model Code Description

The Model code of SenseLink QM defines the features of the Unit for Hardware, software and other options:

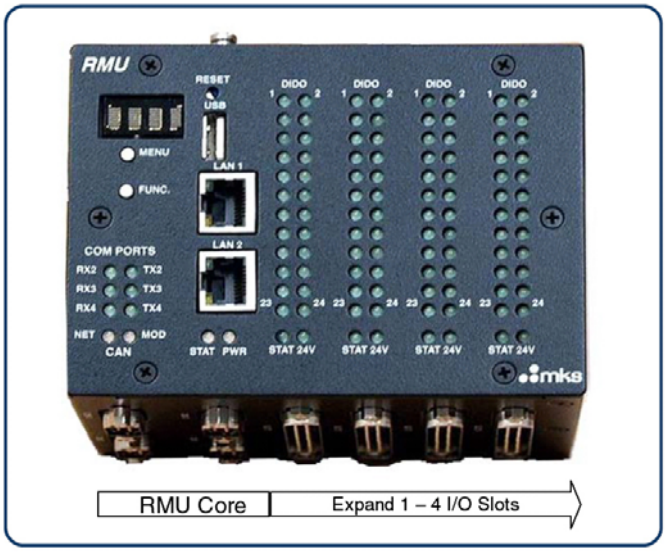
	BASE		OPTIONS		SLOT 1		SLOT 2		SLOT 3		SLOT 4
Format:	**RMU2**	**-**	**C**	**-**	**DIDO**	**-**	**DIDO**	**-**	**DIDO**	**-**	**DIDO**
			D		AIAO		AIAO		AIAO		AIAO
			CF		AHAO		AHAO		AHAO		AHAO
					ACAO		ACAO		ACAO		ACAO
					COMB		COMB		COMB		COMB

Options

-C	With CAN and (2) additional RS232/485 ports
-D	With Display and Function Keys
-CF	CompactFlash, range 64MB to 8GB

Slot Designations

-DIDO	24 Channel Digital I/O Card
-AIAO	16SE/8DIFF Analog In, 8SE Analog Out
-AHAO	16SE/8DIFF Analog Inputs (1M ohm), 8SE Analog Out
-ACAO	8DIFF Analog Inputs (Current Type Inputs), 8SE Analog Out
-COMB	Combination: 16DIDO, 4AI-DIF, 2AO-DIF



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10 Specifications

Physical Specifications

Criteria	Specifications
Dimensions	4” H x 4” W x 2”D plus 0.8” per I/O slot
I/O Connectors	37-pin male D-sub
Ethernet Connector	100 BaseT, RJ45 with EMI filter,LED indicators
RS-232 Connector	DB9 male connector
Weight	600g (1.32 lb)

Environmental Specifications

Criteria	Specifications
Operating Temperature	0 to +55°C
Storage	-40 to +85 °C
Humidity	5 to 95% non-condensing

RMU Core - Functional Specifications

Criteria	Specifications
PowerPC 5200	400 MHz, 760 MIPS with support of floating point instructions
On board Flash	16 MB
SDRAM	128 MB
Real Time Clock	Battery backed, lithium ion
CompactFlash Port	Type I,II
Ethernet Ports	(2) 10/100 independent Ethernet controllers
Serial Ports	(4) Total. (2)RS232 and (2) RS232/485 software selectable.
BUS Interface	2 isolated Ethernet ports – Modbus/TCP or Ethernet/IP
CAN Port	DB9 Connector, Isolated CAN2.0 port.
USB	USB V1.1 compliant
Front Panel Indicators	Network Status, Module Status, LINK, 100MB
Rotary Switches	IP address, operating mode

Power Specifications

Criteria	Specifications
DC Input	18 – 30 VDC Powered from pluggable 5.0mm connector 10 W for RMU Core (500mA at 24VDC) 5-17 W per I/O card
Certifications	CE pending

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Input/Output Specifications per Card

Criteria	Specifications
DIDO Card	
Number of Digital I/O	24 points (input or output)
Power	Requires 24VDC +/-10% for each card
Polarity	Active High/Low selectable for each set of 12 I/O via connector jumper
Response Time	50µsec for DI to interrupt
Digital Input Current sinking Current sourcing	Minimum current of 0.5mA turn-on 0-5V ON 18-24V ON
Digital Output Current sinking Current sourcing Current max	 Active low, 200 mA max / channel Active high, 200 mA max / channel 750 mA per 6 DO
AIAO Card	
Power	Internal +/-15VDC for analog reference, 1W
Accuracy	0.1% Full scale (-10V to 10V)
Ripple	+/- 5mV
Analog Response Time	200 µsec
Analog Input Resolution Hardware Filter Voltage Range Current Range	16 single-ended points or 8 differential points (s/w selectable) 14 bit 1Khz RC filter (specials available on request) -10V to 10V 0 to 20mA with 250ohm input impedance
Analog Output Resolution Voltage Range Capacity	8 single-ended points 12 bit –10 to +10V 5mA / channel into a 2 KΩ load
COMBO Card	
Digital I/O	16 points (input or output)
Analog Inputs	4 AI, Differential Voltage
Analog Outputs	2AO, Differential Voltage
Power	Requires 24VDC +/-10% for each card
NOTE:	For all other COMB card specifications, see above DIDO and AIAO cards

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